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ON THE CONSTITUTION OF THE ALKALOID ISOLATED FROM THE BARK OF *CHLOROXYLON SWIETENIA*, D.C.

BY (MISS) ASIMA MOOKERJEE AND PRAFULLA KUMAR BOSE

From the matured bark of *Chloroxylon swietenia*, D.C. an alkaloid, m.p. 176-77° and a bitter crystalline substance, m.p. 186° have been isolated. The alkaloid has been proved to be identical with skimmianine, previously isolated from six *Rutaceous* species by various workers.

Chloroxylon swietenia, D.C., commonly known as Indian satin wood, is indigenous to India and it belongs to the family *Meliaceae*.

Auld (*J. Chem. Soc.*, 1909, **95**, 964) and Boorsma (*Meded S'Lands Plantent*, 1899, **31**, 105, 131) isolated from the bark of this species an alkaloid, chloroxylonine, m.p. 182-183°, having the molecular formula $C_{18}H_{11}O_3N(OMe)_4$. Chloroxylonine was found to be *laevorotatory* and it developed dermatitis when applied to the skin (Cash, *Brit. Med. J.*, October 7, 1911). The yield of alkaloid being very poor and the method of extraction being extremely laborious, these workers did not further study its properties or determine its constitution.

The present investigation was undertaken with a view to establishing the constitution of chloroxylonine. The bark of the plant was kindly supplied by Dr. K. P. Biswas, Superintendent of the Royal Botanic Garden, Sibpur, Howrah, and Mr. S. N. Bal, Curator of the Industrial Section, Indian Museum, Calcutta, to whom the authors' best thanks are due.

The method of isolation adopted in the present work was quite different from, and simpler than that used by Auld and others (*vide supra*). The bark was dried in the sun, crushed, soxhletted with ether. An alkaloid was isolated from the ether extract by digestion with aqueous hydrochloric acid. The residual ether extract, which contained non-basic constituents, on subsequent evaporation left a bitter, crystalline substance, m.p. 186°. The nature of the alkaloid is the subject matter of the present communication.

The analytical data of the pure crystalline base and its picrate indicate the formula $C_{14}H_{13}O_4N$ which is confirmed by M.W. data. It is free from any *N*-methyl (Herzig and Meyer, *Ber.*, 1894, **27**, 319; *Monatsh*, 1894, **15**, 613; 1897, **18**, 382) and methylenedioxy groups (Gaebel, *Arch. Pharm.*, 1910, **248**, 207) but shows the presence of three methoxyl groups when tested by the method of Zeisel-Pregel-Viebock (*Ber.*, 1930, **63**, 2881, 3207; *Monatsh*, 1885, **6**, 989; 1886, **7**, 406). No acetyl or benozyl derivative could be prepared. Evidently the nitrogen atom is tertiary in character.

The analytical data of the base, its properties and reactions suggested that it might be identical with skimmianine (I), an alkaloid isolated from six different *Rutaceous* species, namely *Skimmia japonica*, Thunb (Honda, *Arch. Expt. Pathol. Pharm.*, 1904, **52**, 83; Asahina and Inubase, *Ber.*, 1930, **63**, 2056; Späth and Neufeld, *Ber.*, 1938, **71B**, 353; Takeda, *J. Pharm. Soc. Japan*, 1941, **61**, 117), *Skimmia repens*, Nakai (Asahina, Ohta and Inubase, *Ber.*, 1930, **63B**, 2045), *Skimmia laureola*, Hook (Chopra, Chatterjee, Dey and Ghosh, *J. Indian Med. Res.*, 1938, **26**, 481), *Orixa japonica*, Thunb (Takesiso,

J. Pharm. Soc. Japan, 1939, **59**, 136), *Fagara mantschurica*, Honta (Ryosuke, *J. Pharm. Soc. Japan*, 1944, **61**, 91) and *Fagara Coco* (Gill) Engl (Stucherts and his collaborators, *Investigationes del Laboratorio de quimica Biologica* Coroba, Argentine, 1, 1933, 2, 1938 ; Deulofeu, Labriola and Murusabal, *J. Amer. Chem. Soc.*, 1943, **65**, 1357). An authentic specimen of skimmianine being not available our compound was degraded to an aldehyde and an acid, the latter being further subjected to decarboxylation. The properties of these compounds were compared with the corresponding products obtained from skimmianine. These are presented in Table I. It will be seen from the data that the alkaloid isolated by us from *C. swietenia* is most probably identical with skimmianine (I).

(I)   (II)   (III)   (IV)
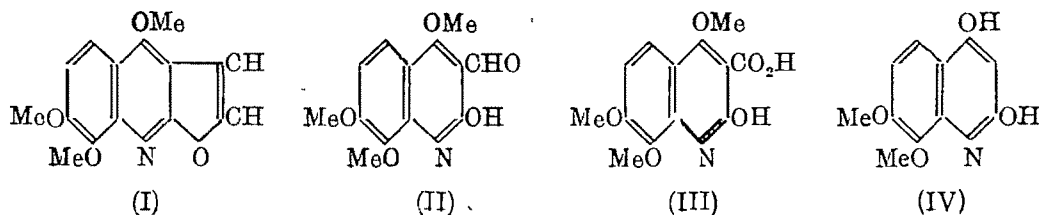
TABLE I

	Alkaloid from	
	C. swietenia.	Skimmianine.
M.p.	176-77°	176°
Mol. formula	$C_{14}H_{13}O_4N$	$C_{14}H_{13}O_4N$
Optical activity	Nil	Nil
Picrate		
M.p.	197-98° (decomp.)	195-97° (decomp.)
Mol. formula	$(C_{14}H_{13}O_4N).C_6H_3O_7N_3$	$(C_{14}H_{13}O_4N),C_6H_3O_7N_3$
Chloroplatinate		
Mol. of formula	$(C_{14}H_{13}O_4N)_2.H_2PtCl_6$	$(C_{14}H_{13}O_4N)_2.H_2PtCl_6$
M.p.	Chars when heated above 200° but does not melt	Not recorded
Degradation products		
(a) Aldehyde (Formula II)		
M.p.	238° (decomp.)	238° (decomp.)
Mol. formula	$C_{10}H_4O_2N(OMe)_3$	$C_{10}H_4O_2N(OMe)_3$ (Skimmianal)
Phenylhydrazone of (a)		
M.p.	210° (decomp.)	210° (decomp.)
Mol. formula	$C_{19}H_{19}O_4N_3$	$C_{19}H_{19}O_4N_3$
(b) Acid (Formula III)		
M.p.	248° (decomp.)	248° (decomp.)
Mol. formula	$C_{13}H_{13}O_6N$	$C_{13}H_{11}O_6N$ (Skimmianic acid)
(c) Decarboxylation product of the acid (b) (Formula IV)		
M.p.	250° (decomp.)	250° (decomp.)
Mol. formula	$C_{11}H_{11}O_4N$	$C_{11}H_{11}O_4N$
(d) Nitroso derivative of (c)		
M.p.	246° (decomp.)	246° (decomp.)

E X P E R I M E N T A L

Isolation of Skimmianine.—The sun-dried, matured bark of *Chloroxylon swietenia* (4 kg.) was powdered in a mortar and sieved. The fine powder was extracted with ether (3 litres) for 48 hours in a soxhlet. The deep brown ethereal extract was concentrated to 500 c.c. and digested with 0.1% hydrochloric acid (300 c.c., in 5 instalments) when the base completely passed into the acid layer (A) as tested with Dragendorff's reagent. The ethereal solution was evaporated to a small bulk (100 c.c.) and kept in the frigidaire when it deposited a bitter crystalline substance (B) (4.0 g., yield 0.1 %), m.p. 186°. This will be the subject matter of a future communication.

The acid digest (A ; *vide supra*) was cooled in ice and carefully basified with aqueous sodium bicarbonate. The precipitate was vigorously shaken up with ether thrice (in 100 c.c. portions) when the base passed into the ether layer. The pale yellow ether extract was twice washed with water, dried over anhydrous sodium sulphate and distilled. The residue was an oil which slowly solidified to a crystalline mass (2.0 g., yield 0.05%). This was successively crystallised from ethyl acetate, alcohol and acetone in glistening colourless prisms till the m.p. became constant at 176°. There was no loss in weight when the crystals were dired in *vacuo* over P_2O_5 for 3 hours at 100°.

[Found : C, 65.06 ; H, 4.92 ; N, 5.31 ; OMe, 35.62 ; M. W. (by chloroplatinate method), 266, 268. $C_{14}H_{15}O_4N$ requires C, 64.86 ; H, 5.02 ; N, 5.40 ; OMe, 35.96 per cent. M.W. 259].

The base is optically inactive and its solution in alcohol is neutral to litmus. Being a weak base, it does not form stable salts with mineral acids and can be quantitatively precipitated from its acid solution by sodium bicarbonate. The base does not contain any water of crystallisation and its alcoholic solution does not produce any colouration with ferric chloride. Its behaviour towards various reagents is recorded in Table II.

TABLE II

Reagent.	Colour
1. Concentrated H_2SO_4	Pale yellow solution with a green fluorescence.
2. Concentrated HNO_3	Orange red changing to red.
3. Erdman's reagent	Pale yellow, changing to red, finally to orange red.
4. Frohde's reagent	Pale yellow changing to olive green after a day.
5. Mandelin's reagent	Dirty yellow changing to olive green and finally to emerald green.

The base gives an orange precipitate with potassium bismuth iodide, a white precipitate with Meyer's reagent, a chocolate brown precipitate with a solution of iodine in potassium iodide and a crystalline yellow precipitate with picric acid, and an orange crystalline compound with chloroplatinic acid.

The base is readily soluble in acetone, fairly in chloroform, sparingly in ethyl acetate, benzene and ether, and insoluble in petroleum ether and water. The alkaloid readily dissolves in aqueous hydrochloric, nitric, and sulphuric acids but the corresponding salts could not be isolated in the pure state.

Picrate of the Base.—The picrate of the base was prepared by adding an ethereal solution of picric acid to an ethereal solution of the base (0.15 g.). The yellow precipitate was collected, washed with ether and a little cold alcohol. It crystallised from alcohol in lustrous shining yellow silky needles (0.12 g.), m.p. 197-98° (decomp.). [Found in a specimen dried in *vacuo* over P_2O_5 for 3 hours at 100° : C, 49.45 ; H, 3.25 ; N, 11.78. $C_{14}H_{13}O_4N.C_6H_2(OH)(NO_2)_3$ requires C, 49.18 ; H, 3.28 ; N, 11.48 per cent].

Chloroplatinate.—It was readily prepared by adding an excess of platinic chloride solution (5%) to a solution of the base in hydrochloric acid. The orange crystalline precipitate was filtered, washed with water slightly acidulated with hydrochloric acid. It was purified by three crystallisations from boiling water, when orange yellow plates were obtained. The chloroplatinate did not melt but charred when heated above 200°. Found in a sample dried in *vacuo* over P_2O_5 for 3 hours at 110° : Pt, 20.7, 20.6. $(C_{14}H_{13}O_4N)_2.H_2PtCl_6$ requires Pt, 21.01 per cent].

Oxidation with Potassium Permanganate.—Oxidation by means of potassium permanganate was carried out by the method of Asahina (*Ber.*, 1930, **63**, 2056). The solution of the base (0.5 g.) in acetone (30 c.c.) was gently refluxed on a water-bath and a neutral solution of potassium permanganate in acetone (1.0 g. in 20 c.c. acetone) was added in small portions. The solution was then refluxed for ½ hour, cooled and filtered (filtrate *a*). The brown precipitate of manganese dioxide (residue *b*) separating was thoroughly washed with boiling acetone and the washings were added to the filtrate (*a*).

Isolation of Skimmianine Aldehyde (Skimmianal).—The combined pale yellow filtrates were freed from the solvent and the residue was digested with aqueous sodium bicarbonate and filtered. The filtrate (*c*) and the residue (*b*) (*vide supra*) were subsequently worked up for the acid (*vide infra*). The residue insoluble in sodium bicarbonate was twice crystallised from acetone. The shining yellow needles (0.20 g.) thus, obtained, melted at 238° (decomp.). (Found in a sample dried in *vacuo* over P_2O_5 for 3 hours at 100° : C, 59.50 ; H, 4.86 ; N, 5.51 ; OMe, 35.12. $C_{13}H_{13}O_5N$ requires C, 59.31 ; H, 4.94 ; N, 5.32 ; OMe, 35.36 per cent).

Phenylhydrazone of the Aldehyde.—The alcoholic solution of the aldehyde (0.15 g.) was refluxed with freshly distilled phenylhydrazine (0.4 g.) and glacial acetic acid (0.5 c.c.). The product was poured into cold water and the resulting precipitate crystallised from alcohol in yellow needles (0.1 g.) melting at 210° (decomp.). On further crystallisation from alcohol and other solvents there was no rise in the m.p. (Found in a sample dried in *vacuo* over P_2O_5 for 3 hours at 100° : N, 12.00. $C_{19}H_{19}O_4N_3$ requires N, 11.93 per cent).

Isolation of Skimmianine Acid (Skimmianic acid).—The mixture of manganese dioxide residue (*b*) and the sodium bicarbonate filtrate (*c*) (*vide supra*) was thoroughly digested with more sodium bicarbonate solution and filtered. The filtrate (50 c.c.) was cooled in ice, acidified with hydrochloric acid (congo red). The flocculent precipitate was collected and crystallised from glacial acetic acid in colourless needles (0.12 g.), m.p. 248° (decomp.). (Found in a sample dried in *vacuo* over P_2O_5 for 3 hours at 100° : C, 55.63 ; H, 4.71 ; N, 4.99 ; OMe, 33.51. $C_{13}H_{13}O_6N$ requires C, 55.91 ; H, 4.66 ; N, 5.02 ; OMe, 33.33 per cent).

Decarboxylation of the Acid.—The acid (0.15 g.) was suspended in dilute hydrochloric acid in water (20 c.c.) and refluxed. After 4 hours the acid completely dissolved with evolution of carbon dioxide. On concentrating the light pink solution (to 5 c.c.) colourless crystals separated (0.05 g.). These were collected and crystallised from alcohol. The needles melted at 250° (decomp.). It readily dissolves in alkali and alkali carbonates. (Found in a sample dried in *vacuo* over P_2O_5 for 3 hours at 100° : C, 58.02 ; H, 4.86 ; N, 6.41 ; OMe, 27.85. $C_{11}H_{11}O_4N$ requires C, 59.73 ; H, 4.98 ; N, 6.33 ; OMe, 28.05 per cent).

Nitroso derivative of the Decarboxylation Product.—The decarboxylation product (0.03 g.) was dissolved in potassium hydroxide (1 c.c.) and the calculated amount of sodium nitrite (0.06 g.) was added to the solution. The mixture was dropped to a cooled solution of 10% sulphuric acid with shaking. The reddish precipitate, thus obtained, was filtered, washed with cold water and crystallised from acetic acid in red needles, m.p. 246° (decomp.). (Found in a sample dried in *vacuo* over P_2O_5 for 3 hours at 100°: N, 11.10. $C_{11}H_{10}O_4N_2$ requires N, 10.91 per cent).

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THE ALKALOID OF *RAUWOLFIA CANESCENS*, LINN. PART IV. ON THE CONSTITUTION OF RAUWOLSCINE

By (Miss) Asima Mookerjee

Rauwolscine, the alkaloid of *Rauwolfia canescens*, Linn., when distilled with zinc dust gives *iso*quinoline, harman and skatole.

The skeletal structure (I) has previously been suggested for rauwolscine, the alkaloid of *Rauwolfia canescens*, Linn. (Mookerjee, *J. Indian Chem. Soc.*, 1941, **18**, 33) and has been based on a study of its reactions, properties and its degradation into harman, *iso*phthalic acid, 3-ethyl-indole and indole-2-acid (Mookerjee, *J. Indian Chem. Soc.*, 1941, **18**, 485; 1943, **20**, 11).

(I)   (II) *iso*Quinoline.
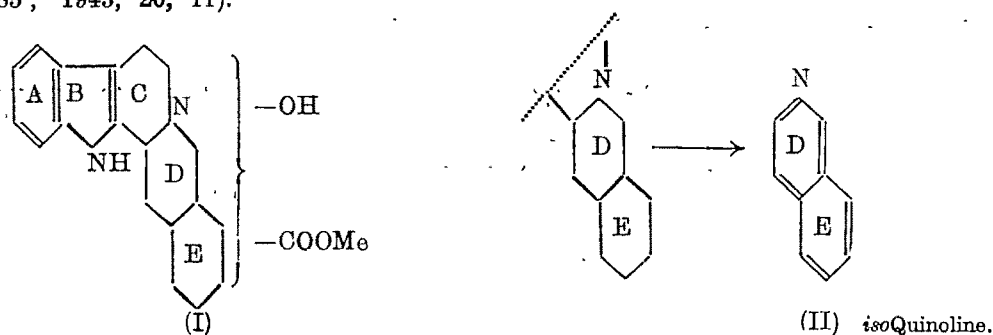
The rings A, B, C and E in (I) could be definitely established by the isolation of harman and *iso*phthalic acid but no definite evidence could be produced for the presence of ring D. The union of the *cyclo*paraffin rings D, E through the tertiary nitrogen atom was assumed to explain the properties and reactions of the base and also in view of the similarity of the degradation products obtained from yohimbine and rauwolscine (Mookerjee, *J. Indian Chem. Soc.*, 1941, **18**, 33, 485; 1943, **20**, 11). In search of some positive evidence of the presence of ring D, rauwolscine has been subjected to further degradations. The results are discussed in the present communication.

Rauwolscine on distillation with zinc dust gives *iso*quinoline, harman and skatole. Now, *iso*quinoline (II) can only originate through fission of the alkaloid at the dotted line.

The ring AB being an indole residue may be expected to produce quinolines but not *iso*quinolines. The formation of *iso*quinoline is regarded as a definite proof of the presence of ring D in rauwolscine.

Experimental

Zinc dust distillation of Rauwolscine.—Rauwolscine (8 g.) was mixed up with zinc dust (40 g.) and heated strongly in a combustion tube over free flame, the air having been previously replaced from the system by a current of hydrogen. The reaction mass was kept stirred by rotating the tube which was heated up to redness within 10 minutes.

The heating was continued for 1 hour. The products of distillation were passed through a 5% solution of hydrochloric acid. When the tube cooled down, the residue in the tube was thrice digested with ether (50 c.c each time). The red ethereal digest was mixed up with the hydrochloric acid solution containing other products of distillation mentioned above and shaken energetically in a separating funnel. In this way two fractions were obtained : An aqueous acid solution (*a*) and an ethereal fraction (*b*).

The wine coloured acid solution (*a*) was basified with aqueous sodium hydroxide when a viscid mass separated. It was taken up in ether and the ether layer was washed with water and dried over anhydrous sodium sulphate. The residue obtained after removal of ether was subjected to high vacuum distillation when it yielded two fractions, distilling at 65-70°/0.3 mm. and at 160-80°/0.1 mm. respectively.

Isolation of isoQuinoline.—The fraction boiling at 65-70° was a pale yellow liquid (0.35 g.) having a quinoline like odour. It was purified by redistillation in *vacuo* at 65-70°/ 0.3 mm. The liquid when freshly distilled was colourless but gradually turned brown on exposure to air. With an ethereal solution of picric acid, the liquid produced a yellow precipitate which crystallised from alcohol in shining yellow needles, m.p. 215-17°, (decomp.). [Found in a specimen dried in *vacuo* at 100° for 4 hours over P_2O_5 : N. 15.72. $C_9H_7N.C_6H_2(NO_2)_3OH$ requires N, 15.64 per cent]. It showed no depression in m.p. when mixed with a specimen of the picrate of synthetic *iso*quinoline.

Chloroplatinate of isoQuinoline.—An aqueous solution of platinic chloride (5%) was slowly added to an aqueous solution of the above *iso*quinoline (0.25 c.c.) dissolved in hydrochloric acid. The orange precipitate was collected and washed with cold water containing a little hydrochloric acid. The precipitate crystallised from water in shining orange needles, m.p. 262-64° (decomp.). [Found at 100° : Pt, 29.35. $(C_9H_7N)_2.H_2PtCl_6$ requires Pt, 29.18 per cent). It showed no depression in m.p. when mixed with a specimen of the chloroplatinate of synthetic *iso*quinoline.

Isolation of Harman.—The pale yellow viscid mass which distilled at 160-80°/0.1 mm. was extracted with hydrochloric acid (1%). The major portion of the distillate dissolved, leaving only a little gummy mass. The solution was filtered and basified with an aqueous solution of sodium hydroxide and the base liberated was drawn into ether. The ethereal solution was again extracted with hydrochloric acid, the base was librated from the acid solution and this process of purifying the base was repeated thrice. The purified base was obtained as a semisolid mass and was distilled in *vacuo* when a pale yellow solid (0.12 g.) sublimed at 160-80°/0.1 mm. The sublimate crystallised from benzene in colourless needles, m.p. 230°. (Found in a specimen dried in *vacuo* over P_2O_5 for 4 hours at 110° : C, 79.2 ; H, 5.43 ; N, 15.40. $C_{13}H_{10}N_2$ requires C, 79.12 ; H, 5.49 ; N, 15.38 per cent). The melting point did not change when the crystals were mixed with a synthetic specimen of harman.

Isolation of Skatole from the ethereal fraction (b).—The ethereal solution (*b*) was washed with water, dried over anhydrous sodium sulphate. The residue obtained after evaporation of ether yielded on steam distillation, a pale yellow oil with a faecal smell like that of skatole. The oil distilled at 100-110°/0.1 mm. and formed a pale yellow solid,

m.p. 90° on cooling (0.15 g.). On repeated crystallisations from benzene it melted at 93°. The oil turned gradually red when exposed to air. It imparted a red colour to a pine chip moistened with concentrated hydrochloric acid. Mixed with skatole there was no depression in m.p. (Found in a sample dried in *vacuo* over P_2O_5 for 4 hours at 60° : C, 82.63 ; H, 7.12 ; N, 10.93. C_9H_9N requires C, 82.43 ; H, 6.87 ; N, 10.69 per cent). With picric acid it produced a scarlet-red picrate which crystallised from benzene in needles, m.p. 169-71° (decomp.). [Found in a sample dired in *vacuo* over P_2O_5 for 4 hours at 100° : N, 15.12. $C_9H_9N.C_6H_2OH(NO_2)_3$ requires N, 15.55 per cent). The picrate showed no depression in m.p. when mixed with skatole picrate which melted alone at 172°.

The author wishes to offer her best thanks to Dr. P. K. Bose and Prof. P. C. Mitter for their keen interest in the work and the facilities given.

SYNTHESIS OF NEW LOCAL ANAESTHETICS. PART VII

BY K. N. GAIND AND P. N. VOHRA

Some diethylamino and piperidino derivatives of acetyl—and propionylaminoanilines have been prepared and their local anaesthetic properties studied.

It has been established by Gaind, Ray and co-workers (*J. Indian Chem. Soc.*, 1940, 17, 400, 619) that a simple amido group in a compound can act as anchor for the production of local anaesthetic properties. It has been shown (*loc. cit.*) that quinolines having the side-chain in position 8 were found to have pronounced local anaesthetic properties, yet its value as a therapeutic is very doubtful as the quinolines are well known irritants. In the present work the quinoline group has been replaced by an aniline group, thus synthesising substances with non-irritating properties of the general formula

NH$_2$

NHCO(CH$_2$)$_n$R
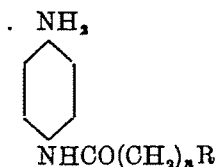
where $n=1$ or 2 and R=N-Et$_2$ or piperidyl. The NH$_2$ may be in *ortho, meta,* or *para* position.

The dihydrochloride of *o*-amino-β-diethylaminopropionanilide, and *p*-amino-β-piperidinopropionanilide have been found to have as strong anaesthetic properties as cocaine hydrochloride, when tested by Rabbit's cornea method.

EXPERIMENTAL

Preparation of p-*Nitrochloroacetanilide.*—*p*-Nitroaniline (2 g.) was suspended in dry benzene (30 c.c.) and a solution of chloroacetyl chloride (1.4 c.c.) in dry benzene (20 c.c.) was added to it gradually during 15 minutes at 15°. It was refluxed on a water-bath for 2 hours and then cooled. The yellow precipitate was washed several times with water, dried and crystallised from alcohol as yellow plates, m.p. 191°. (Found : N, 13.11 ; Cl, 16.55. C$_8$H$_7$O$_3$N$_2$Cl requires N, 13.08 ; Cl, 16.53 per cent).

p-*Nitropiperidinoacetanilide.*—The solution of the above chloro compound (2 g.) in absolute alcohol (30 c.c.) with piperidene (2 c.c.) was refluxed on a water-bath for 4 hours. On cooling, needles separated out which after being washed several times with water rerystallised from absolute alcohol as rectangular plates, m. p. 143-44°. (Found : N, 15.76. C$_{13}$H$_{17}$O$_3$N$_3$ requires N, 15.97 per cent).

p-*Aminopiperidinoacetanilide.*—Piperidinoacetyl-*p*-nitroaniline (2 g.) was dissolved in acetic acid (30 c.c., 50%) and zinc dust (14 g.) was added to it in small quantities at a time. The temperature at once rose to 40° and was maintained as such throughout the addition of zinc dust. Afterwards it was heated on a water-bath at 60° for 3 hours and filtered. The filtrate was cooled in ice and ammonium chloride (20 g.) was added

to it. The reaction mixture was made alkaline with ammonia and extracted with ether. The ethereal extract was dried over anhydrous sodium sulphate and ether recovered. The residue thus obtained was dissolved in dry ether and treated with ethereal hydrogen chloride till acidic. On cooling in ice for 2 hours a white product separated out which was washed with dry ether repeatedly and then crystallised from alcohol-ether mixture, m.p. 258-59° (decomp.). (Found : N, 13.4 ; Cl, 22.98. $C_{13}H_{21}ON_3Cl_2$ requires N, 13.6 ; Cl, 23.2 per cent).

p-*Nitrodiethylaminoacetanilide.*—It was prepared using the corresponding chloro compound (3 g.) in absolute alcohol (50 c.c.) and adding diethylamine (4.3 c.c.) in an analogous way and was crystallised from low boiling petroleum ether as long needles, m.p. 69-70°. (Found : N, 16.35. $C_{12}H_{17}O_3N_3$ requires N, 16.66 per cent).

TABLE I

Name of substance	Crystallised from	M.p.	Found,	Calc.
			Analysis	
o-Nitrochloroacetanilide	Dil. alcohol	94°	N, 13.4%	N, 13.08%
			Cl, 16.3	Cl, 16.37
o-Nitrodiethylaminoacetanilide	,,	72°	N, 16.45	N, 16.7
o-Aminodiethylaminoacetanilide dipicrate	Alcohol-ether	193° (decomp.)	N, 18.58	N, 18.56
o-Aminopiperidinoacetanilide dipicrate	Acetone-ether	245° (decomp.)	N, 18.37	N, 18.29
o-Nitro-β-chloropropionanilide	Dil. alcohol	90°	N, 12.4	N, 12.3
			Cl, 15.1	Cl, 15.53
o-Nitro-β-diethylaminopropionanilide picrate	Alcohol-benzene	162-63°	N, 17.36	N, 17.1
o-Amino-β-diethylaminopropionanilide dipicrate	Alcohol-benzene	180°	N, 18.82	N, 18.2
o-Nitro-β-piperidinopropionanilide dipicrate	,,	174°	N, 16.21	N, 16.5
o-Amino-β-piperidinopropionanilide dipicrate	,,	170°	N, 18.72	N, 18.2
m-Nitrochloroacetanilide	,,	174°	N, 13.3	N, 13.08
			Cl, 16.4	Cl, 16.37
m-Nitropiperidinoacetanilide	Dil. alcohol	95°	N, 15.5	N, 15.97
m-Aminopiperidinoacetanilide dipicrate	,,	200°	N, 18.5	N, 18.29
m-Nitrodiethylaminoacetanilide	Benzene	47°	N, 16.5	N, 16.7
m-Aminodiethylaminoacetanilide dipicrate	,,	109°	N, 18.53	N, 18.56
m-Nitro-β-chloropropionanilide	Alcohol	97°	N, 12.1	N, 12.3
			Cl, 15.2	Cl, 15.53
m-Nitro-β-diethylaminopropionanilide	Dil. alcohol	88-90°	N, 15.7	N, 15.9
m-Amino-β-diethylaminopropionanilide dipicrate	Alcohol-ether	220-21° (decomp.)	N, 18.5	N, 18.2
m-Nitro-β-piperidinopropionanilide	Dil. alcohol	199°	N, 15.3	N, 15.16
m-Amino-β-piperidinopropioanilide dipicrate	Alcohol-benzene	110°	N, 18.4	N, 18.2

p-*Aminodiethylaminoacetanilide dihydrochloride* was also prepared in a manner analogous to the corresponding piperidine compound. It was crystallised from alcohol-ether mixture, m.p. 237-38° (decomp.). (Found : N, 14.0 ; Cl, 23.9. $C_{12}H_{21}ON_3Cl_2$ requires N, 14.3 ; Cl, 24.1 per cent).

p-*Nitro-β-chloropropionanilide* was prepared using p-nitroaniline (5 g.) in dry benzene (60 c.c.) and a solution of β-chloropropionyl chloride (3 c.c.) in dry benzene (10 c.c.) in a manner already described for chloroacetyl compound. It was crystallised from alcohol in yellow needles, m.p. 171°. (Found : N, 13.2 ; Cl, 15.79. $C_9H_3O_3N_2Cl$ requires N, 12.8 ; Cl, 15.52 per cent).

p - *Nitro - β - diethylaminopropionanilide* was prepared from the foregoing chloro compound in the usual way. It was crystallised from low boiling petroleum ether as long white needles, m.p. 96°. (Found : N, 15.5. $C_8H_{19}O_3N_3$ requires N, 15.9 per cent). '

p-*Amino-β-diethylaminopropionanilide dihydrochloride* was prepared in a similar way as described for the corresponding acetyl compound, and crystallised from alcohol-ether mixture, m.p. 335° (decomp.). (Found : N, 13.9 ; Cl, 23.2. $C_{13}H_{23}ON_3Cl_2$ requires N, 13.8 ; Cl ; 23.05 per cent).

TABLE II

(The figures in the paranthesis are for cocaine which is used as standard)

Substance	Time for onset of anaesthesia : complete loss of reflex action	Duration for which complete loss of reflex action lasted
p-Aminodiethylaminoacet--anilide dihydrochloride	Never complete (1 minute)	Incomplete anaesthesia lasted for 4 minutes (37 minutes)
p-Aminopiperidinoacetanilide dihydrochloride	Never complete (1 minute)	Incomplete anaesthesia lasted for 25 minutes (36 minutes)
p-Amino-β-diethylaminopropion-anilide dihydrochloride	Never complete (1 minute)	Incomplete anaesthesia lasted for 15 minutes (36 minutes)
p-Amino-β-piperidinopropiona-nilide dihydrochloride	4 minutes (1½ minute)	36 minutes (37 minutes)
o-Aimnodiethylaminoacetani-lide dihydrochloride	5 minutes (1½ minute)	30 minutes (35 minutes)
o-Aminopiperidinoacetanilide-dihydrochloride	6 minutes (1 minute)	20 minutes (36 minutes)
o-Amino-β-diethylaminopropio-nanilide dihydrochloride	2 minutes (1 minute)	36 minutes (36 minutes)
o-Amino-β-piperidinopropionani-lide dihydrochloride	Never complete (1½ minute)	Incomplete anaesthesia lasted for 20 minutes (37 minutes)
m-Aminodiethylaminoacetanilide dihydrochloride	Never complete (1 minute)	Incomplete anaesthesia lasted for 20 minutes (37 minutes)
m-Aminopiperidinoacetanilide dihydrochloride	Never complete (1½ minute)	Incomplete anaesthesia lasted for 15 minutes (36 minutes)
m-Amino-β-diethylaminopropion-anilide dihydrochloride	5 minutes (1 minute)	20 minutes (37 minutes)
m-Amino-β-piperidino-propiona-nilide dihydrochloride	Never complete (1 minute)	Incomplete anaesthesia lasted for 30 minutes (36 minutes)

p - *Nitro - β - piperidinopropionanilide* was prepared from the corresponding chloro compound, in an analogous way as described for diethylamino compound using piperidine in place of diethylamine. It was crystallised from 50% alcohol, m.p. 100° (decomp.). (Found : N, 14.96. $C_{14}H_{19}O_3N_3$ requires N, 15.16 per cent).

p-*Amino-β-piperidinopropionanilide* was prepared in a similar way by the reduction of the above nitro compound as rectangular plate, m.p. 96°. (Found : N, 17.2. $C_{14}H_{21}O_2N_3$ requires N, 17.05 per cent.)

The *dihydrochloride* was crystallised from alcohol-ether mixture, m.p. 335° (decomp.). (Found : N, 13.12; Cl, 21.6. $C_{14}H_{23}ON_3Cl_2$ requires N, 13.16 ; Cl, 21.7 per cent).

The compounds prepared from *o*- and *m*-nitroanilines are shown in Table I.

The above substances were tested for local anaesthetic activity by rabbit's cornea method and Table II shows the results.

From the foregoing table it appears that dihydrochlorides of *o*-amino-β-diethylaminopropionanilide, and *p*-amino-β-piperidinopropionanilide have as strong anaesthetic properties as cocaine hydrochloride. The time for onset of anaesthesia, however, is longer in these cases than with cocain hydrochloride.

The authors are very thankful to Dr. J. N. Ray, Director, Drugs and Dressing, Department of Supply, New Delhi, for his keen interest in this work.

ON THE PREPARATION OF SULPHANILAMIDE DERIVATIVES. PART III. SULPHATHIAZOLES

By P. K. Das-Gupta and P. Gupta

A method has been described by which various sulphathiazoles may be prepared by the action of yellow ammonium sulphide on an alkali salt of sulphanilylcyanamide and subsequent condensation of the resulting sulphanilylthiourea with chloroaldehydes and ketones.

Sulphathiazole (2-p-aminobenzenesulphonamidothiazole) (I) is a valuable antibacterial agent, particularly against pneumococcus (Mckee *et al.*, *Proc. Soc. Expt. Biol. Med.*, 1939, **42**, 410). It is generally prepared by the action of 2-aminothiazole on *p*-acetaminobenzenesulphonyl chloride and subsequent hydrolysis (Fosbinder and Walter, *J. Amer. Chem. Soc.*, 1939, **61**, 2032 ; Svensk, *Kem. Tid.*. 1942, **52**, 64) according to the following equations :—

$$CH_3.CO.NH.C_6H_4SO_2Cl + NH_2—C\overset{S——CH}{\underset{N}{\big|\ \ \big|}}CH \longrightarrow$$

$$CH_3CONH.C_6H_4.SO_2NH—C\overset{S——CH}{\underset{N}{\big|\ \ \big|}}CH \xrightarrow{H_2O} NH_2.C_6H_4.SO_2NH—C\overset{S——CH}{\underset{N}{\big|\ \ \big|}}CH \quad (I)$$
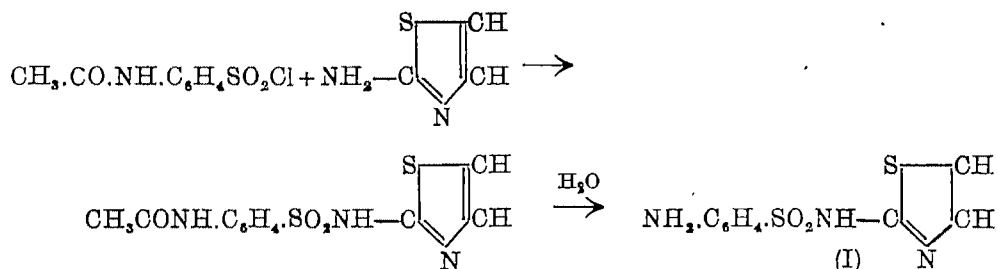
By another process (Indian Patent No. 26850) the same compound has been obtained from *p*-aminobenzenesulphonamide and 2-bromothiazole. By yet another process (I.P. 28108) this compound is obtained from *p*-acetaminobenzenesulphonyl chloride and sodium derivative of 2-aminothiazole and subsequent hydrolysis.

In Part II (Das-gupta and Gupta, *J. Indian Chem. Soc.*, 1945, **22**, 327) it has been shown that the cyanamide grouping of sulphanilylcyanamide reacts with ammonia to give rise to sulphaguanidine.

$$NH_2C_6H_4.SO_2NH.CN \xrightarrow{NH_3} NH_2C_6H_4.SO_2NH.C\underset{NH_2}{\overset{NH}{<}}$$
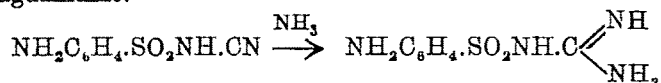
Cyanamide is known (Baumann, *Ber.*, 1875, **8**, 26) to react with sulphuretted hydrogen to give rise to thiourea

$$NH_2.CN + H_2.S \longrightarrow H_2N.C\underset{SH}{\overset{NH}{<}}$$
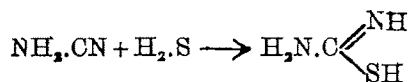
As thiourea again readily reacts with α-haloid keto compounds (*Ber.*, 1887, **20**, 3127) to give rise to aminothiazoles according to the equation

$$NH_2.C\underset{NH}{\overset{SH}{<}} + \underset{CO.R}{\overset{Cl.CH_2}{|}} \longrightarrow NH_2—C\overset{S——CH}{\underset{N}{\big|\ \ \big|}}C.R$$
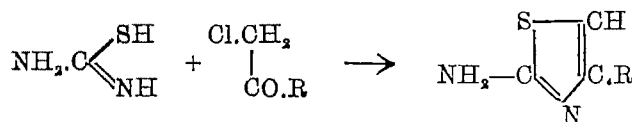
it has been considered to be of interest to study the above reactions with sulphanilyl-cynamide, prepared according to the method previously described by us in Part I of this series (*J. Indian Chem. Soc.*, 1945, 22, 324) by reacting *p*-aminobenzene sulphonamide with ethyl sulphocyanide, in the expectation of working out a process for the manufacture of sulphathiazole according to the following scheme :

$$NH_2.C_6H_4.SO_2NH_2 \xrightarrow{RSCN} NH_2.C_6H_4.SO_2.NH\cdot CN \xrightarrow{H_2S}$$

$$NH_2.C_6H_4.SO_2NH.C\underset{NH}{\overset{SH}{<}} \xrightarrow{ClCH_2CO.R} NH_2.C_6H_4.SO_2.NH-C\underset{N}{\overset{S-CH}{\diagdown\diagup}}C.R$$
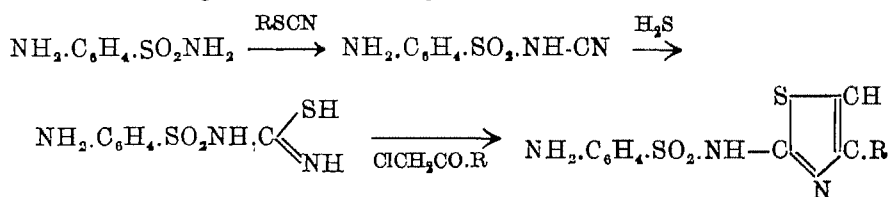
This expectation has been fully realised and the details of the experimental procedure are embodied in this paper.

EXPERIMENTAL

p-*Aminobenzenesulphonylthiourea.*—Sodium salt of *p*-aminobenzenesulphoncynana-mide (20 g.) was added to a saturated solution of yellow ammonium sulphide (150 c.c.) and the solution left as such for 40 hours. The solution was then evaporated to dryness on a water-bath and the residue again treated with water, and filtered. The filtrate on aci-dification with dilute acid gave a solid turning yellow mercuric oxide black. *p*-Amino-benzenesulphonylthiourea crystallised from water in needles, m.p. 169-70°. (Found : N, 18.2 ; S, 27.9. $C_7H_9O_2N_3S_2$ requires N, 18.18 ; S, 27.7 per cent).

p-*Acetaminobeneznesulphonylthiourea.*—The sodium salt of *p*-acetaminobenzenesul-phoncyanamide, isolated by reacting the sodium salt of *p*-acetaminobenzenesulphon-amide (27 g.) with ethyl sulphocyanide, was dissolved in about 200 c.c. water. Saturated yellow ammonium sulphide solution (80 c.c.) was added to it in cold and the solution kept at the room temperature for 40 hours. It was filtered and the filtrtae was evaporated off on a water-bath. The residue was boiled with water and filtered to remove any undesir-able by-product. The filtrate on acidification afforded *p*-acetylaminobenzenesulphonyl-thiourea, m.p. 195°. (Found : N, 15.18 ; S, 23.4. $C_9H_{11}O_3N_3S_2$ requires N, 15.38 ; S, 23.48 per cent).

2-(p-*Aminobenzene sulphonamido*)-*thiazole.*—Dichloroethyl ether (12.0 g.) was sus-pended in water in a a conical flask and mixed with calcium carbonate (4 g.). The calcium carbonate went into solution and the solution became neutral to congo-red, *p*-Amino benzenesulphonylthiourea in the form of its sodium salt.(20 g.) was added to the above solution which was refluxed for 1 hour. The hot solution was decanted into a beaker and allowed to cool. Reddish brown crystals were obtained which were first crystallised from water and then from dilute alcohol. This melted at 202° and gave all charac-teristics of 2-(*p*-aminobenezenesulphonamido)thiazole. (Found : N, 16.8. $C_9H_9O_2N_3S_2$ requires N, 16.47 per cent).

2 - (*p* - *Acetaminobenzenesulphonamido*) - *thiazole.*—Dichloroethyl ether (15 g.) was treated with sodium salt of *p*-acetaminobenzenesulphonylthiourea (30 g.) in the way as illustrated in the above example and the mixture refluxed on a wire gauge for 2 hours. The reaction mixture on cooling gave a reddish brown mass which crystallised from dilute

alcohol, m.p. 256°. (Found : N, 14.25. $C_{11}H_{11}O_3N_3S_2$ requires N, 14.14 per cent). On hydrolysing with caustic soda solution (10%) it afforded 2-(p-aminobenzenesulphon-amido)-thiazole, m.p. 202°.

2-(p-Aminobenzenesulphonamido)-4-methylthiazole.—The sodium salt of p-amino-benzenesulphonylthiourea was taken in absolute alcohol and then refluxed with molecular proportion of chloroacetone for about 15 minutes. The reaction mixture was diluted with water when crystals separated out. This on recrystallisation from dilute alcohol melted at 237° without sintering when admixed with an authentic sample of 2-(p-amino-benzenesulphonamido)-4-methylthiazole. (Found : N, 15.72. Calc. for $C_{10}H_{11}O_2N_3S_2$: N, 15.6 per cent.)

2-(p-Aminobenzenesulphonamido)-4-phenylthiazole.—2-(p-Aminobenzenesulphonamido)-4-phenylthiazole, m.p. 190°, was similarly obtained by reacting the sodium salt of p-amino-benzenesulphonylthiourea with ω-bromoacetophenone in a way as illustrated above. (Found : N, 12.9. $C_{15}H_{13}O_2N_3S_2$ requires N, 12.7 per cent.)

2-(p-Aminobenzenesulphonamido)-4 : 5-tetrahydrobenzothiazole.—The sodium salt of p-aminobenzenesulphonylthiourea was similarly reacted in molecular proportion with 2-chlorocyclohexanone in alcoholic suspension. The reaction mixture on subsequent treatment afforded 2-(p-aminobenzenesulphonamido)-4: 5-tetrahydrobenzothiazole, m.p. 154° already described by Basu and Das-gupta (*J. Indian Chem Soc.,* 1941, **18**, 167). (Found : N, 12.70 ; H_2O, 5.4. $C_{13}H_{15}O_2N_3S_2$, H_2O requires N, 12.84 ; H_2O, 5.5 per cent).

2-(p-Acetaminobenzenesulphonamido)4-methylthiazole.—Soduum salt of p-acetamino-benzenesulphonylthiourea, as prepared before, was refluxed with molecular proportion of chloroacetone in absolute alcohol for about 20 minutes. The reaction mixture was cooled and diluted with water when a solid separated out. This melted at 259° and on hydrolysis with alkali in the customary way afforded 2-(p-aminobenzenesulphon-amido)-4-methylthiazole. (Found : N, 13.65. $C_{12}H_{13}O_3N_3S_2$ requires N, 13.5 per cent).

2-(p-Acetaminobenzenesulphonamido)-4-phenylthiazole.—Sodium salt of p-acetamino-benzene sulphonylthiourea was treated as above with ω-bromoacetophenone. The acetyl derivative first isolated melted at 235° and this on hydrolysis in the usual way afforded 2-(p-aminobenzenesulphonamido)-4-phenylthiazole. (Found : N, 11.5. $C_{17}H_{15}O_3N_3S_2$ requires N, 11.3 per cent).

2-(p-Acetaminobenzenesulphonamido)-4 : 5-tetrahydrobenzothiazole.—2-Chlorocyclohe-xanone and sodium salt of p-acetaminobenzenesulphonylthiourea when reacted as above gave a thiazole derivative, m.p. 180°, which on hydrolysis as usual gave 2-(p-amino-benzenesulphonamido)-4: 5-tetrahydrobenzothiazole. (Found : N, 11.5 ; H_2O, 5.0. $C_{15}H_{17}O_3N_3S_2$, H_2O requires N, 11.4 ; H_2O, 4.9 per cent).

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PYRONES AND RELATED COMPOUNDS. PART IV. SELF-CONDENSATION OF 1 : 3 : 5-TRIKETONES

By R. KAUSHAL

Diacetylacetone and dipropionylacetone undergo self-condensation in presence of piperidine to form dihydroxyacetyl-alkyl-naphthalenes.

It is well known that monoketones R_1-CO-CH$_3$ (I) condense with itself or with another ketone of the type R_1-CO-R$_2$ (II) to give unsaturated monoketones R_1R_2C : CH-CO-R$_1$ (III). Thus acetone gives mesityl oxide (III, $R_1=R_2=CH_3$). The reaction is brought about by hydrochloric acid gas.

Acetyl acetone, a typical diketone, does not undergo self-condensation in presence of hydrochloric acid but only acetic acid and acetone together with some unchanged acetylacetone are recovered, very likely due to acid hydrolysis of the ketone. To avoid possibility of hydrolysis hydrochloric acid has been replaced by diethylamine or piperidine but acetyl acetone is recovered unchanged. Sodium ethylate also gives negative result. However, Huckel (*British Chem. Abstracts*, 1935, *i*, 204) condensed acetyl acetone with itself on boiling with very dilute hydrochloric acid to afford 4-acetyl-*m*-5-xylenol (V). This is formed possibly through (IV) which in the enolic form loses a molecule of water giving (V) thus :

CH$_3$—CO—CH$_2$—CO—CH$_3$ +   CO—CH$_2$—CO—CH$_3$ —→
|
CH$_3$

Enolisation   CH$_3$—CO—CH$_2$—CO—CH=C—CH$_2$—CO—CH$_3$
|
(IV)   CH$_3$

−H$_2$O
—→

(V)
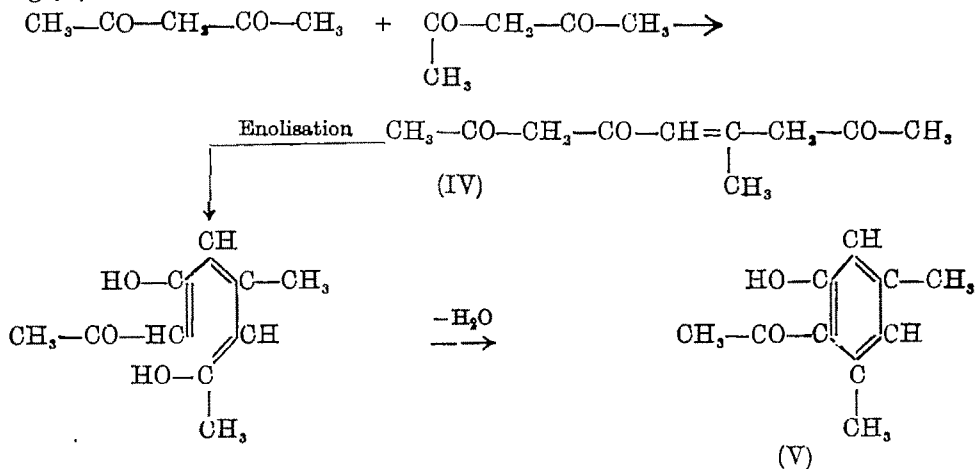
Diacetylacetone, a typical triketone, has the structure (VI, R = R' = H) (*cf.* Deshapande, Dingankar and Kokil, *J. Indian Chem. Soc.*, 1934, **11**, 595 ; Bedekar, Kaushal and Deshapande, *ibid.*, 1935, **12**, 466).

(VII)

R—CH$_2$CO—CH$_2$—CO—CH$_2$—CO—CH$_2$.R'

OH · · OH

R.CH$_2$—C=CH—CO—CH=C—CH$_2$R'
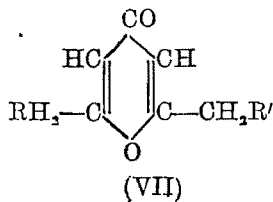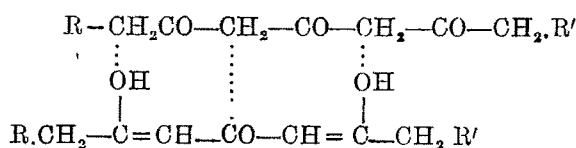
(VI)

↓ Very dil. alkali

(IX)
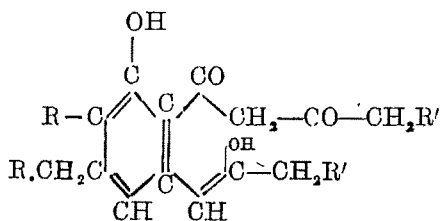
↓ Enolise

(VIII)

Conc. alkali ——————→
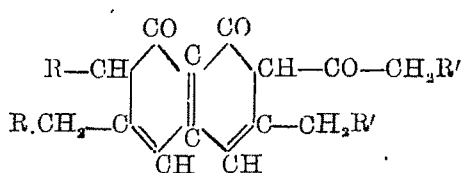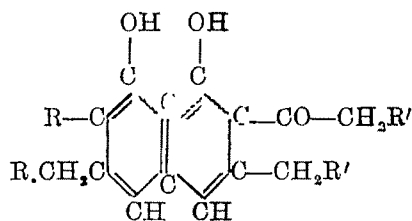
(X)

It contains in its molecule two reactive methylene groups. With sodium ethylate it forms its own sodium derivative and with acid condensing agents it forms dimethyl pyrone (VII, R=R'=H). With basic condensing agents like piperidine it undergoes self-condensation like the other mono or diketones to form a product C$_{14}$H$_{14}$O$_3$. This proved to be dihydroxydimethylacetyl naphthalene (X, R=R'=H) obtained by Collie and Myers (*J. Chem. Soc.*, 1893, **63**, 122) through the intermediate benzene derivative (IX, R=R'=H). In the formation of (X) in presence of piperidine two molecules of diacetyl-acetone one in the enolic and the other in the ketonic form, react to form the intermediate product (VIII) which enolises to (X). Dihydroxydimethylacetyl naphthalene forms a diacetyl derivative which has been found identical with that described by Collie.

The homologue dipropionyl acetone (VI, R=R'=CH$_3$; Deshapande, Dingankar and Kokil, *loc. cit.*) which with acid condensing agents gives diethyl pyrone (VII, R=R'=CH$_3$) gives similarly with piperidine a self-condensation product (C$_{18}$H$_{22}$O$_3$) which by analogy is dihydroxydiethylmethylpropionyl naphthalene (X, R=R'=CH$_3$).

EXPERIMENTAL

Diacetylacetone was prepared by the action of strong baryta on dimethyl pyrone which was obtained from dehydracetic acid by the action of hydrochloric acid.

Self-condensation of Diacetylacetone (VI, R=R'=H) to *Dihydroxydimethylacetyl Naphthalene* (X, R=R'=H).—Diacetylacetone (4 g.) was heated with a few drops of piperidine in a small tube with a loose cork in a water-bath for 1 hour. The water drops formed during the reaction and collected on the cooler parts of the tube were removed from time to time. On cooling, the semi-solid yellow mass was rubbed with benzene and filtered, yield 2.5 g. This was crystallised from boiling benzene or glacial acetic acid as thin yellow needles, m. p. 181°. (Found: C, 72.8; H, 5.6. C$_{14}$H$_{14}$O$_3$ requires C, 73.0; H, 6.1 per cent).

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The dihydroxy derivative of dihydroxydimethylacetyl naphthalene was obtained by boiling the solid melting at 181° with acetic anhydride and a drop of sulphuric acid.' On cooling and pouring the reaction mixture in water, the diacetyl derivative separated as a solid which after crystallisation from dilute alcohol melted at 169°. This was found identical with that described by Collie melting at 168°.

Self-condensation of Dipropionylacetone (VI, R = R′ = CH$_3$).—Dipropionylacetone underwent similar self-condensation like diacetylacetone and gave a viscous oil which on rubbing with dilute hydrochloric acid gave the condensation product as yellow crystalline mass; crystallised from benzene it melted at 122°. (Found : C, 75.0 ; H, 7.0. C$_{18}$H$_{22}$O$_3$ requires C, 75.5 ; H, 7.6 per cent).

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PYRONES AND RELATED COMPOUNDS. PART V. ACTION OF ACID CHLORIDES ON COPPER DIACETYLACETONE

BY V. B. BILLORE, R. P. NIGAM, R. KAUSHAL AND S. S. DESHAPANDE

The action of carbonyl chloride, oxalyl chloride and malonyl chloride on copper diacetylacetone results respectively in the formation of diacetyl*cyclo*butane-dione, diacetyl*cyclo*pentane-trione and diacetyl*cyclo*hexane-trione. which is most stable. Diacetyl*cyclo*butane-dione is very unstable being broken into two molecules of acetyl keten which recombine in a different manner to form dehydracetic acid thereby confirming Feist's formula for the substance.

Deshapande and co-workers have given the structure (I) to diacetylacetone (*J. Indian Chem. Soc.*, 1934, **11**, 596 ; 1935, **12**, 466). Copper salt of the triketone on this basis should be represented by (II) and therefore it should be possible to replace the copper by suitable groups by the action of acid chlorides *e.q.*, carbonyl chloride in this manner should give *cyclo*butane-1 : 3-dione (III).

(1)

(II)

(III)

(IV)

(V)

(VI)

$$CH_3-CO-HC \overset{CO}{\diamond} CH-CO-CH_3 \qquad CH_3-CO-CH_2 \overset{CO}{\diamond} CH_2-CO-CH_3$$

(VII) ... 2HOH $\longrightarrow$ ...
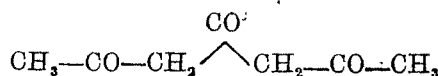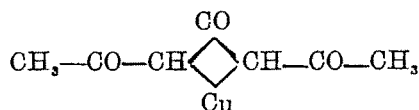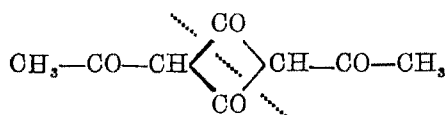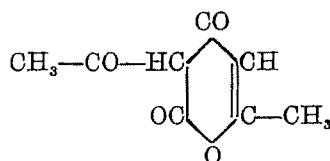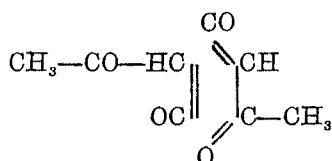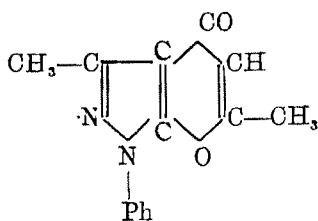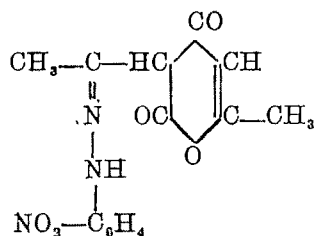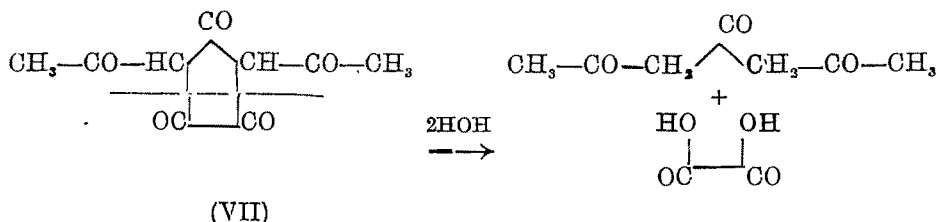
Copper diacetylacetone and carbonyl chloride react in molecular proportion to give a solid, m.p. 110°. The analysis agrees with the formula $(C_8H_8O_4)$ which is that of the cyclobutane-dione (III) and it was thought that the desired substance was obtained but the reactivity of one carbonyl group instead of two or four could not be explained. The melting point suggested that the new compound may be dehydracetic acid $C_8H_8O_4$ (IV), though the possibility was remote. It is surprising to note that the mixed melting point with an authentic sample of dehydracetic acid gives no depression. A series of the following derivatives from the new compound and (IV) have been found identical : Copper salt, semicarbazone and para-nitrophenylhydrazone. This left no doubt as to the identity of the new compound with dehydracetic acid.

It is difficult to realise the formation of dehydracetic acid, unless we assume the unstability of cyclobutane-dione (III). Then it seems likely that the compound (III) is undoubtedly formed at first which undergoes ring fission due to the unstability of the cyclobutane-dione ring giving rise to two molecules of acetyl keten which then recombine in a different manner to form one molecule of dehydracetic acid (IV) as shown above (cf. Chick and Willsmore, J. Chem. Soc., 1908, 93, 946). This incidental synthesis of dehydracetic acid proves that the structure (IV) assigned to it by Feist is correct and that Collie's structure is unlikely. This has been proved by Rasweiler and Adams (J. Amer. Chem. Soc., 1924, 46, 2758) on other grounds also.

It is important to note that the action of nitrophenylhydrazine on dehydracetic acid seems to be somewhat different from that of phenylhydrazine which in molecular proportion gave the pyrazole derivative (V) (Stole, Ber., 1905, 38, 3026). With nitrophenylhydrazine a simple nitrophenylhydrazone is formed. It is not easy to say which of the three carbonyl groups has yielded to phenylhydrazone formation. But as far as one could go by analogy, the nitrophenylhydrazone has probably the structure (VI).

The action of oxalyl chloride on copper diacetylacetone gives the expected diacetyl cyclopentane-trione (VII). In this reaction much carbon dioxide is evolved showing that the compound (VII) is not the only product of the reaction and must be accompanied by other side products. The diacetyl cyclopentane-trione is a solid, m.p. 176°. It gives coloration to ferric chloride and does not form a copper salt. It is rather unstable and when left in contact with water, it hydrolyses to diacetylacetone and oxalic acid which were isolated and identified. It forms a pentasemicarbazone.

Ingold (J. Chem. Soc., 1921, 119, 305) has pointed out that the lower cyclic monoketones like cyclopropanone are less stable than their corresponding polymethylenes; while the higher cyclic monoketones are more stable than their corresponding polymethylenes. The stability of the compounds (III) and (VII) is in agreement with this view although it is to be noted that the number of the ketonic groups in (III) is two and in ((VII) is three

Proper comparison would be afforded between (VII) and diacetyl *cyclo*hexane-trione (VIII) which is obtained by the action of malonyl chloride on copper diacetylacetone.

(VIII)   (IX)   (X)

(XI)   (XII)   (XIII)
m.p. 115°   m.p. 156°   m.p. 105°
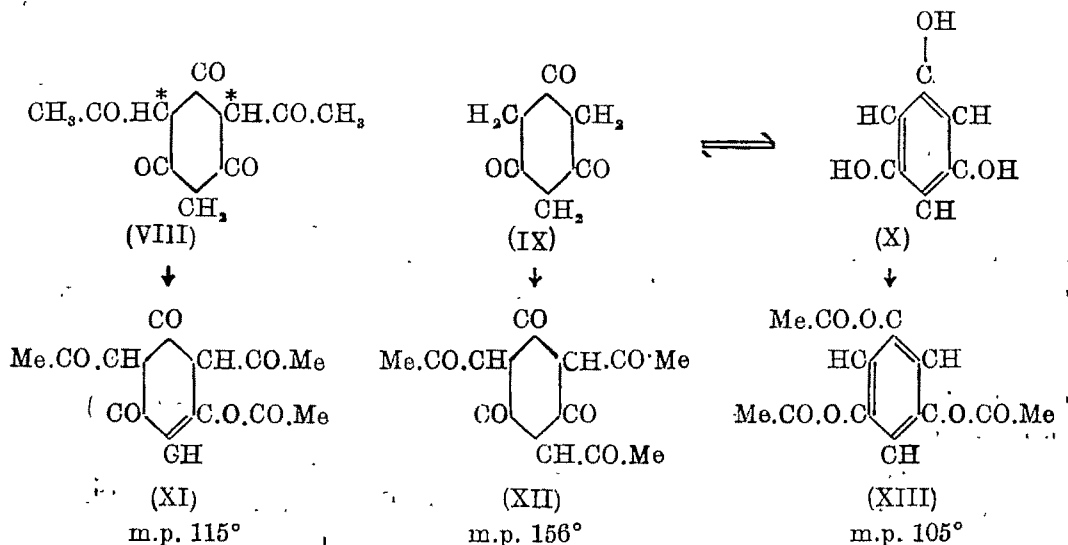
Diacetyl*cyclo*hexane-trione is a pale yellow solid, m.p. 171° and unlike (VII) it is more stable and could be boiled with aqueous alcohol without rupture of the ring. This is the effect of introducing one methylene group in the molecule of (VII). Since diacetyl-*cyclo*hexane-trione (VIII) is a derivative of *s*-*cyclo*hexane-trione (IX) which is tautomeric to phloroglucinol (X), a resemblance between (VIII) and (X) is expected. This has been realised. Like phloroglucinol it is slightly acidic and gives an intense violet colour to ferric chloride. It dissolves in caustic soda, which with excess of alkali darkens on exposure to air as happens in the case of phloroglucinol and more readily in the case of pyrogallol. Like the latter it reduces alkaline copper sulphate, though somewhat slowly.

Phloroglucinol in a sealed tube with zinc chloride and acetic anhydride at 150° gives the triacetyl derivative (XII) but when refluxed with acetic anhydride gives 1 : 3 5-triacetate (XIII). Diacetylphloroglucinol (VIII) when boiled with acetic anhydride gives a compound m.p. 115° of the composition $C_{12}H_{12}O_6$ which is that of the monoacetyl derivative (XI). Theoretically a triacetyl derivative is expected but probably the two acetyl groups in the molecule of (VIII) interfere with the migration of two hydrogen atoms marked with asterisk to form a tri-enolic structure.

EXPERIMENTAL

Copper diacetylacetone (II) was prepared by adding to a cold alcoholic solution of diacetylacetone a saturated solution of copper and sodium acetates when the apple green coloured copper diacetylacetone precipitated as a crystalline solid. It was washed free from copper acetate and dried at 110°, yield almost theoretical.

Action of Carbonyl Chloride on Copper Diacetylacetone : Formation of Dehydracetic Acid. —To a suspension of copper salt (16 g.) in dry benzene (70 c.c.) in a round-bottomed flask fitted with a good cork carbonyl chloride in benzene (57 g., 14.4%) was gradually added

in about three quarters of an hour under ice-cooling. The reaction flask was kept in ice-chest for 4 days when the reaction was complete and the benzene layer became dark orange in colour which was filtered and the gummy mass on washing with hot benzene left copper chloride in the funnel. The benzene extract was washed with water, dried over calcium chloride and after removing the excess of benzene the residual liquid crystallised out as yellow needles on cooling in a basin. This was recrystallised from dilute alcohol as beautiful pale yellow needles, m.p. 110°. (Found : C, 58.0 ; H, 5.5. $C_8H_8O_4$ requires C, 57.1 ; H, 4.8 per cent).

The *semicarbazone* of dehydracetic acid was prepared in the usual manner and crystallised from alcohol as colourless shining needles, m.p. 198-99° (decomp.). Bülow and Fisher (*Ber.*, 1908, **41**, 4161) recorded m.p. 197-98°. This was found identical with the semicarbazone prepared from a genuine specimen of dehydracetic acid.

The *nitrophenylhydrazone* (VI) was prepared by refluxing an alcoholic solution of the substance and a little more than one molecule of *p*-nitrophenylhydrazine for 20 minutes on a water-bath. This was filtered hot and on cooling the nitrophenylhydrazone separated. which was crystallised from acetic acid as short thick brown needles, m.p. 226-27° (decomp.). (Found : C, 55.6 ; H, 4.8 ; N, 14.4. $C_{14}H_{13}O_5N_3$ requires C, 55.4 ; H, 4.3 ; N, 13.9 per cent).

. *Action of Oxalyl Chloride on Copper Diacetylacetone : Formation of Diacetylcyclopentane-trione* (VII).—Copper salt (15 g.) was suspended in dry benzene (80 c.c.) in a round-bottomed flask fitted with a calcium chloride tube and oxalyl chloride (9.5 g., 1 mol) was added gradually in an hour under ice-cooling. Slow effervescence could be seen in the flask and a small quantity of gas was being evolved which was identified to be carbon monoxide. The reaction flask as before was left in ice for 4 days and after the reaction was over, the contents were filtered at the pump when a black gritty mass was left on the funnel. This was rubbed with water to remove copper chloride, dried on a porous plate and again washed with benzene to remove the colour when the diacetyl *cyclo*pentane-trione was left as a brown solid, yield 8 g. It crystallised from ethyl acetate as short shining star-shaped needles, m.p. 176° (decomp.). (Found : C, 54.6 ; H, 3.9. $C_9H_8O_5$ requires C, 55.1 ; H, 4.1 per cent). 0.086 G. of the substance reacted with 4.43 c.c. $N/10$-caustic soda and 4.38 c c. are required theoretically.

On working up the benzene layer a small quantity of a solid insufficient for further work was obtained which when crystallised from ethyl acetate melted at 170°.

Hydrolysis of Diacetylcyclopentane-trione.—The aqueous washings of the black gritty mass consisting of (VII) contained copper chloride and some of the substance (VII). From this solution a light blue coloured copper salt separated on standing for some time which on decomposing with concentrated hydrochloric acid on warming and ether extraction gave a crystalline acid which was characterised as oxalic acid by its m.p. and reactions.

The remaining aqueous filtrate after removal of copper oxalate above on extraction with hot ethyl acetate gave a sweet smelling liquid which solidified on scratching, m.p. 50°. This was identified as diacetylacetone by its small, colour reaction to ferric chloride, m.p. and the formation of copper salt by comparison with a genuine sample of diacetylacetone.

Action of Water on Diacetylcyclopentane-trione.—A little of the pure cystallised substance melting at 176° was dissolved in water and left for some time. The solution was divided in two parts. To one portion on adding copper and sodium acetates and warming a green coloured copper salt was precipitated at once which on decomposition with dilute hydrochloric acid gave diacetylacetone. To the second portion was added copper chloride when a light blue coloured copper salt was formed the quantity increasing on warming, which on decomposition with warm strong hydrochloric acid and ether extraction gave oxalic acid.

The *penta-semicarbazone of* (VII) crystallised from dilute acetic acid as small white needles, m.p. 259° (decomp.). (Found : N, 43.3. $C_{14}H_{33}O_5N_{15}$ requires N, 43.8 per cent).

Diacetylcyclohexane-trione (VIII).—Copper diacetylacetone (5 g.) was suspended in dry benzene (30 c.c.) in a flask and malonyl chloride (3.5 g.) diluted with an equal volume of dry benzene was gradually added under efficient ice-cooling. The flask was corked and left in ice for a day and after filtering the supernatant red benzene layer, the residual semi-solid mass was stirred with water. The thick dark green coloured liquid which resulted on stirring with water was filtered and allowed to crystallise. After standing for a day the crystalline solid separating was filtered, washed free of copper chloride and dried, yield 1.5 g.

It is a pale yellow solid and could be crystallised from alcohol or glacial acetic acid as star-shaped needles, m.p. 171°. (Found : C, 56.8 ; H, 4.4. $C_{10}H_{10}O_5$ requires C, 57.1 ; H, 4.8 per cent.). It is sparingly soluble in benzene or ether, is slightly soluble in water and does not form a semicarbazone like diacetyl*cyclo*pentane-trione (VII).

The *acetyl derivative* (XI) was prepared by boiling the compound (VIII) with excess of acetic anhydride and a drop of sulphuric acid and pouring the dark coloured liquid formed in water when a small quantity of gummy mass separated which was filtered and pressed on a porous tile. The filtrate on evaporation gave a solid mixed with gum which was also pressed on the tile. The two products were separately rubbed with petrol ether and on extraction with hot benzene the acetyl derivative separated as a crystalline solid on cooling, m.p. 115°. (Found : C, 57.6 ; H, 5.3. $C_{12}H_{12}O_6$ requires C, 57.1 ; H, 4.8 per cent.).

PYRONES AND RELATED COMPOUNDS. PART VI. BROMINATION OF DIETHYL AND DI-*n*-PROPYL PYRONES

By A. C. MAHESHWARI, R. KAUSHAL AND S. S. DESHAPANDE

The bromination of diethyl and dipropyl pyrones unlike pyrone and dimethyl pyrone gives only the dibromopyrones and the prolonged action of bromine results in the fission of the pyrone ring to give tetrabromodiacyldiethylene ketones. The mechanism of the reaction is given.

Feist and Baum (*Ber.*, 1905, **38**, 3562) have shown that pyrone (I, R=H) and dimethyl pyrone (I, R=CH$_3$) in their behaviour towards bromine occupy an intermediate position between benzene and pyridine. For, whereas benzene is easily brominated and pyridine is brominated with great difficulty directly by bromine, the pyrones are brominated with moderate ease giving rise to substitution products which brings them in line with benzene or pyridine, whose bromination results in substitution products only.

| | | | | |
| (I) | (II) | (III) | (IV) | (V) |
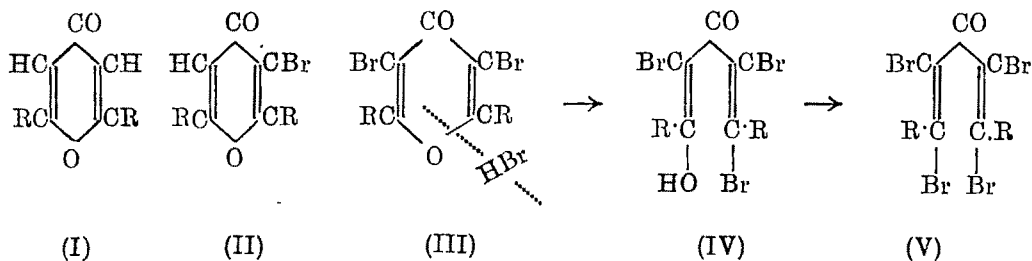
The bromination of diethyl and dipropyl pyrones (I, R=C$_2$H$_5$ or C$_3$H$_7$) synthesised by Deshapande (*J. Indian Chem. Soc.*, 1932, **9**, 304) was expected to give results similar to pyrone and dimethyl pyrone. In the latter the bromine enters the β-position with respect to the ring oxygen and forms 3 : 5-dibromodimethyl pyrone.

Bromination of diethyl pyrone with an excess of bromine gives a solid perbromide of the brominated pyrone which loses bromine on steam distillation and gives 3 : 5-dibromo-diethylpyrone (III, R=C$_2$H$_5$), m.p. 78°. Dipropyl pyrone on similar treatment gives the corresponding bromopyrone (III, R=C$_3$H$_7$) which is a liquid. These bromopyrones do not give the reactions of a ketone and thus resemble the unbrominated pyrones (*cf.* Bedekar, Kaushal and Deshapande, *J. Indian Chem. Soc.*, 1935, **12**, 466). Moreover, they seem to have lost all basic properties as they do not form hydrochloride or chloroplatinate. The bromine atom in them is remarkably stable and so also the oxygen of the ring; for on boiling with strong baryta solution neither the bromine could be replaced by hydroxyl nor the ring could be opened at the oxygen. Sodamide also gives negative results.

Unlike dimethyl pyrone, diethyl and dipropyl pyrones do not give monobromo products like (II). The reaction proceeds even beyond dibromination and the prolonged action on a water-bath brings about the fission of the pyrone ring producing tetrabromo-diethyl or dipropyl diethylene ketones (V, R=C$_2$H$_5$ or C$_3$H$_7$) from the respective pyrones. The pyrone ring undergoes fission by the hydrobromic acid evolved in the reaction to

form the intermediate product (IV) the tertiary hydroxyl group of which immediately reacts with hydrobromic acid to give the olefinic ketone (V) (*cf.* Kamm and Marvel, *J. Amer. Chem. Soc.*, 1920, **42**, 299).

This is not surprising in view of the fact that tetrahydro pyrones are easily split up to diolefinic ketones by mineral acids (*Ber.*, 1897, **30**, 2801 ; 1898, **31**, 1508 ; 1899, **32**, 809). Thus 2 : 6-diphenyltetrahydropyrone gives dibenzalacetone obviously according to the following change :—
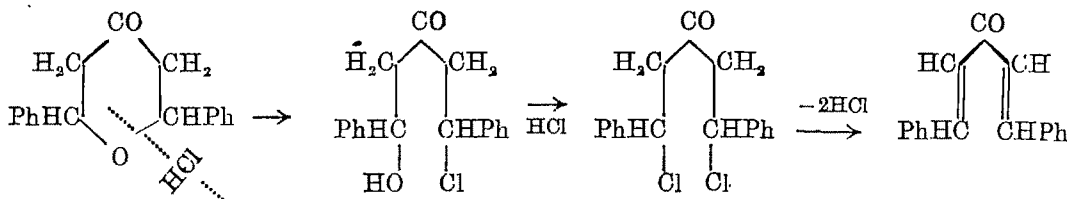
The olefinic ketones (V) are remarkably stable and the peculiarity about them is that they do not react with semicarbazide, phenyl or nitrophenylhydrazine. The inactivity of the carbonyl group is probably due to the steric hindrance offered by the two bromine atoms linked to the adjacent carbon atoms to the carbonyl. They decolourise 1 % acid potassium permanganate solution.

EXPERIMENTAL

3 : 5-*Dibromodiethyl Pyrone* (III, R=C_2H_5).—Diethyl pyrone (4.7 g.) was gradually added in sunlight in about one quarter of an hour to bromine (30 g.), dried over sulphuric acid, containing iodine (0.2 g.) in a flask fitted with a long air condenser and a calcium chloride tube. A vigorous reaction took place in the beginning with evolution of hydrobromic acid, the reaction being completed by heating on a water-bath for 2 hours. On removing the excess of bromine a red crystalline mass separated, which was the perbromide of the brominated pyrone. This was subjected to steam distillation until no more of bromine passed over and the residual oily layer solidified ; yield of the crude product, 6.0 g. (60% of theory). It crystallised from 50% alcohol as long fine colourless needles, m.p. 78°. (Found : C, 34.2 ; H, 3.1 ; Br, 51.1. $C_9H_{10}O_2Br_2$ requires C, 34.8 ; H, 3.2 ; Br, 51.6 per cent).

3 : 5-*Dibromodipropyl Pyrone* (III, R=C_3H_7).—Dipropyl pyrone (4 g.) was added gradually to dry bromine (14 g.) containing a little iodine as before and heated on a water-bath for nearly 4 hours to complete the reaction and after removal of excess of bromine the perbromide was subjected to steam distillation when the bromopyrone came out as a red coloured oil. It did not solidify even in ice and was therefore extracted with ether, dried and on removal of ether the bromopyrone was obtained as a red viscous oil, yield 5 g. On distillation under reduced pressure it decomposed at 140°. (Found : Br, 39.2 in the distilled liquid and Br, 46.8 in the crude product. $C_{11}H_{14}O_2Br_2$ requires Br, 47.3 per cent).

Tetrabromodiethyl-diethylene Ketone (V, R=C_2H_5).—Diethyl pyrone (5 g.) was added in sunlight to bromine (32 g.) dried over sulphuric acid containing a little iodine as before

and the reaction mixture was heated on a water-bath for nearly 6 hours. After going through all the stages as in the preparation of dibromdiethyl pyrone, a mixture of the ketone and the bromopyrone was obtained after steam distillation, yield 10 g. (66% of theory). On shaking the mixture with absolute alcohol, the ketone remained undissolved as a white granular crystalline solid, purified by washing it melted at 165°. (Found: C, 23.4; H, 1.8; Br, 70.3. $C_9H_{10}OBr_4$ requires C, 23.8; H, 2.2; Br, 70.5 per cent).

From the crude product, dissolved in absolute alcohol, the dibromodiethyl pyrone was isolated by repeated crystallisation from 50% alcohol. Though the mixture contained about 70% of the bromo ketone, only 30% of the ketone and 10% of the bromopyrone could be isolated in the pure condition.

Tetrabromodipropyl-diethylene Ketone (V, R=C_3H_7).—Dipropyl pyrone (2.5 g.) was added to bromine (12 g.) containing a little iodine as in the previous experiments and the mixture heated on a water-bath for 10 hours. The excess of bromine was evaporated and the residue on steam distillation gave an oil which solidified in about three to four days. Purified by repeated washings with absolute alcohol it melted at 160°, yield 3.5 g. (Found: C, 28.0; H, 2.8; Br, 66.5. $C_{11}H_{11}OBr_4$ requires C, 27.4; H, 2.9; Br, 66.3 per cent).

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S-BENZYL THIURONIUM DERIVATIVES OF OXYMETHYLENE KETONES

BY M. D. RATNAKAR, R. KAUSHAL AND S. S. DESHAPANDE

S-Benzyl thiuronium chloride reacts in aqueous alcoholic solution with oxymethylene ketones to form well defined crystalline derivatives. In some cases the sodium compounds of the oxymethylene ketones, formed in their preparation, directly react with the reagent whereas in others the ketones must first be exactly neutralised with caustic soda or caustic potash and then made to react with the reagent.

Donlavy (*J. Amer. Chem. Soc.*, 1936, **58,** 1009) has shown that S-benzyl thiuronium chloride (I), prepared from benzyl chloride and thiourea, reacts readily in aqueous alcoholic solution with sodium or potassium salts of organic acids to give crystalline derivatives (II) which may be used to characterise the acids. The reaction proceeds rapidly and in a short time the crystalline derivative (II) is deposited.

$$Ph\ CH_2Cl \atop + \atop S=C(NH_2)_2 \quad \longrightarrow \quad Ph.CH_2\ S.C{\overset{NH_2}{\underset{\underset{Cl}{|}}{\diagdown NH_2}}} \quad \overset{RCOON_a}{\longrightarrow} \quad Ph.CH_2.S.C{\overset{NH_2}{\underset{\underset{R\ CO.O}{|}}{\diagdown NH_2}}}$$

$$(I) \hspace{5cm} (II)$$
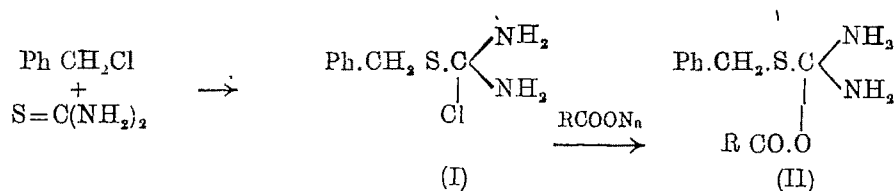
It has been shown by Claisen (*Ber.*, 1887, **20,** 2191 ; 1888, **21,** 915) that the formyl derivatives (IV) of a ketone (III) exist mostly as their enols (V) known as oxymethylene ketones which are strongly acidic and are comparable in this respect to true organic acids.

$$R.CO.CH_2\ R' \qquad R.CO.C.R' \qquad \overset{O}{\underset{O.C.OH}{||}} \qquad Ph.CH_2.S.C{\overset{NH_2}{\underset{|}{\diagdown NH_2}}}$$

$$(III) \qquad\qquad \overset{||}{H.C.OH}$$

$$R.CO.CR'H.CHO \qquad\qquad\qquad\qquad R.CO.CR'=CH.O$$

$$(IV) \qquad\qquad (V) \qquad \text{Formic acid} \qquad (VI)$$
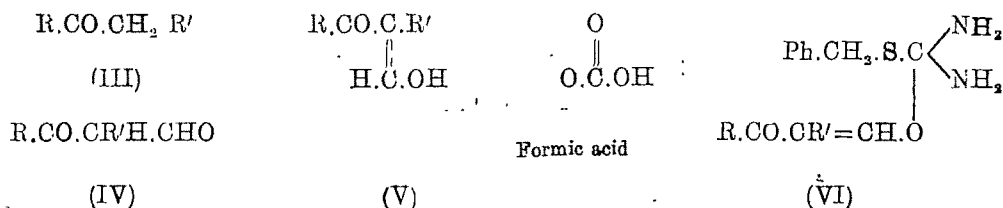
It was, expected, therefore that the sodium compounds of these ketones (V) would also react with S-benzyl thiuronium chloride (I) to give the corresponding derivatives. The preparation of organic derivatives of oxymethylene ketones is important for two reasons. Firstly many of these oxymethylene ketones are unstable and cannot be preserved. They readily undergo self-condensation to form trisubstituted benzenes (Claisen and Stylos, *Ber.*, 1888, **21,** 1145 ; Kaushal, Sovani and Deshapande, *J. Indian Chem. Soc.*, 1942, **19,** 115).

If therefore they could react in the form of their sodium salts, which are stable with S-benzyl thiuronium chloride, a stable organic derivative could be obtained. For example, the sodium salt of oxymethylene acetone (V, R=CH₃ ; R'=H) could give S-benzyl thiuronium oxymethylene acetonate (VI, R=CH₃ ; R'=H).

Secondly since Donlavy (*loc. cit.*) has shown that some of these S-benzyl thiuronium derivatives of organic acids (II) are readily hydrolysed, such derivatives, if they could

be formed from oxymethylene ketones, would serve the purpose of isolation and purification of such ketones.

When the sodium salt of oxymethylene acetone is suspended in absolute alcohol and an alcoholic solution of the reagent (I) is added, the derivative (VI, R=CH_3 ; R′=H) begins to appear in the crystalline form. Freed from sodium chloride and crystallised from alcohol the compound separates in needles, m.p. 140°.

In the case of oxymethylene methylethyl ketone (V, R=R′=CH_3) (*cf.* Kaushal *et al.*, *J. Indian Chem. Soc.*, 1941, **18**, 481 ; 1942, **19**, 116 ; 1943, **20**, 55) the derivative (VI, R=R′=CH_3) has been prepared by two methods. In one method the sodium salt of the ketone (V, R=R′=CH_3) is directly treated with the reagent in alcoholic suspension. In the other the ketone is made exactly neutral by the addition of caustic soda and to the aqueous solution so formed the reagent dissolved in alcohol is added. In both the cases the same compound (VI, R=R′=CH_3) is formed but the yield in the latter method is better. The pure compound crystallises from alcohol and melts at 67-68°.

(VII)   (VIII)
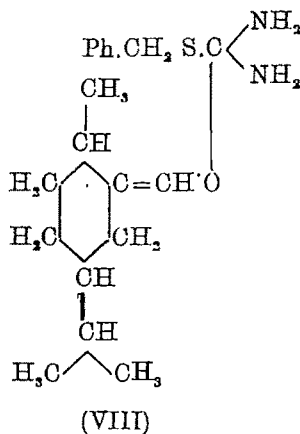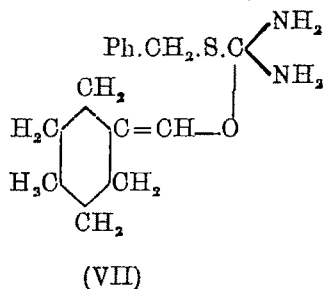
Oxymethylene acetophenone (V, R=C_6H_5 ; R′=H) gives the derivative (VI, R=C_6H_5 ; R′=H) which crystallises from ethyl acetate, m.p. 190°.

Oxymethylene *cyclo*hexanone neutralised with aqueous caustic potash or soda yielded the derivative (VII) which when crystallised from alcohol melts at 120°.

Similarly oxymethylene menthone gives the derivative (VIII) melting at 203°. In the case of oxymethylene *cyclo*hexanone and oxymethylene menthone the solid sodium compounds formed in their preparation fail to give any yield. The derivatives could be obtained only through the ketone neutralised with caustic potash or caustic soda.

EXPERIMENTAL

Preparation of S-Benzyl Thiuronium Chloride. (I).—Benzyl chloride (12.6 g.), thiourea (7.6 g.) and absolute alcohol (200 c.c.) were mixed together and refluxed on a water-bath. At first the thiourea remained undissolved but after about half an hour a vigorous reaction set in and the whole of the thiourea was dissolved. The reaction subsided after 1 hour and the contents were heated for 1 hour more and poured hot in a beaker, when S-benzyl thiuronium chloride separated on cooling. The crude product was crystallised from absolute alcohol as shining plates, m.p. 174°, yield 15 g.

The *oxymethylene ketones* in general were prepared by Claisen's method using 1 mol. of ketone, 1.5 mols ethyl formate and 1.5 atoms of sodium wire in ether under ice-cooling. The sodium compounds, thus formed, were washed from organic matter and used as such. In some cases the sodium compound was decomposed with cold dilute sulphuric acid and the oxymethylene ketone extracted with ether and purified further.

S-Benzyl thiuronium oxymethylene acetonate (VI, R=CH₃ ; R′=H) was obtained in good yield by reacting sodium oxymethylene acetone, suspended in alcohol, with the reagent dissolved in minimum quantity of absolute alcohol in molecular proportion and keeping the reaction mixture for some time when the derivative separated as colourless prisms. Crystallised from absolute alcohol it melts at 140°. (Found : N, 10.8 ; S, 12.9. $C_{12}H_{16}O_2N_2S$ requires N, 11.1 ; S, 12.7 per cent).

Reaction of Oxymethylene Methylethyl Ketone (V, R=R′=CH₃) with *S-Benzyl Thiuronium Chloride*.—A dilute solution of caustic soda (1.7g.) was added to oxymethylene methyl ethyl ketone (3 g.) when a clear solution was obtained. To it 6 g. of the reagent dissolved in minimum quantity of absolute alcohol were added and the mixture allowed to remain when after sometime a crystalline derivative separated which was filtered, dried and recrystallised from absolute alcohol , m.p. 67-68°; yield about 2 g. (Found : N, 10.9 ; S, 12.3. $C_{13}H_{18}O_2N_2S$ requires N, 10.5 ; S, 12.0 per cent).

The *derivative* (VI, R′=H ; R=C₆H₅) from oxymethylene acetophenone (V, R=C₆H₅ ; R′=H. Bülow and Sicherer, *Ber.*, 1901, **34**, 3891) with the reagent (I) was prepared by treating oxymethylene acetophenone (3 g.) as in the previous case with sodium hydroxide (1.1 g.) and 4.1 g. reagent when a crystalline derivative was obtained, which was filtered, dried and recrystallised from ethyl acetate, m.p. 190°, yield 1.5 g. (Found : N, 9.6 ; S, 10.6. $C_{17}H_{18}O_2N_2S$ requires N, 8.9 ; S, 10.2 per cent).

Reaction of S-*Benzyl Thiuronium Chloride with Oxymethylene* cyclohexanone.—Oxy-methylene cyclohexanone, b.p. 79°/4 mm. (2.5 g.) (*cf.* Wallach, *Annalen*, 1903, **329**, 109) was exactly neutralised with a dilute solution of 1.1 g. caustic soda and 4 g. of the reagent dissolved in the minimum quantity of absolute alcohol were added when the crys-talline derivative (VII) was obtained on standing. It was filtered, dried and recrystallised from absolute alcohol, m.p. 120° ; yield 1.5 g. (Found : N, 10.0 ; S, 10.8. $C_{15}H_{20}O_2N_2S$ requires N, 9.6 ; S, 10.9 per cent.)

Reaction of S-*Benzyl Thiuronium Chloride with Oxymethylene menthone*.—Oxymethylene menthone was prepared by the method described by Bishop, Claisen and Sinclair (*Annalen*, 1894, **281**, 394), b.p. 111-112°/5 mm. and 1.5 g. of it were exactly neutralised with a dilute solution of 0.9 g. caustic soda when a clear solution was obtained. To this 1.7 g. of the reagent, dissolved in the minimum quantity of absolute alcohol, were added and the mixture allowed to remain when a crystalline derivative (VIII) separated in small quantity. It re-crystallised from absolute alcohol as almost colourless needles, m.p. 203°, yield 0.5 g. (Found : S, 9.5. $C_{19}H_{28}O_2N_2S$ requires S, 9.2 per cent).

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ON THE STUDY OF LEAD-ACETATO COMPLEX ION

By B. C. Purkayastha and R. N. Sen-Sarma

Various hypotheses regarding the nature of the compound formed when a lead salt is treated with an alkali acetate has been critically examined. From thermometric and conductometric measurements it has been definitely shown that the main reaction results in the formation of a cationic complex, $(Pb-C_2H_3O_2)^+$ and by utilising Job's method of continued variation, the dissociation constant of this complex cation has been determined.

The observation that lead sulphate dissolves in ammonium acetate is of classic application in analytical chemistry. Similar behaviour of other sparingly soluble lead salts towards alkali acetates has been the subject matter of frequent discussion for the last forty years and various hypotheses regarding the nature of the reaction has been proposed from time to time, but unfortunately the conditions under which the experimental data have all been obtained are not free from objections and so the conclusion arrived at cannot be fully relied upon.

The object of the present investigation is to examine the various hypotheses and to study the reaction from different physicochemical standpoint. Thermometric (Dutoit, *J. chim. phys.*, 1921, **19**, 324) and conductometric measurements have been utilised as guiding indicators to ascertain at what proportion the reaction actually takes place and by utilising Job's principle of continued variation (Job, *Compt. rend.*, 1925, **180**, 928) the nature of the complex and its extent of dissociation have been ascertained.

The fact that lead acetate is a poor conductor of electricity led Noyes and Whitcomb (*J. Amer. Chem. Soc.*, 1905, **27**, 747) to suppose that the solubility of lead sulphate in ammonium acetate was due to the formation of undissociated lead acetate by metathesis. From a preparative point of view White (*Amer. Chem. J.*, 1904, **31**, 4) postulated that solubility of sparingly soluble lead salts in alkali acetates was due to the formation of a complex aceto-plumbite anion. Sanved (*J. Chem. Soc.*, 1927, 1967) in a review of the nature of the complex formed, referred to the work of Blomberg (*Chem. Weekblad*, 1914, **II**, 1030) and that of Canrad (*Diss. Gottingen*, 1903) on the complex nature of lead acetate itself and summing up all the evidences known till then he put forward the hypothesis that the ion formed is probably $[Pb.C_2H_3O_2]^+$, a result of primary dissociation of lead acetate. Edmonds and Birnbaum (*J. Amer. Chem. Soc.*, 1940, **62**, 2367) very recently from a study of the solubility of lead iodate in ammonium acetate at constant ionic strength in the presence of varying acetate ion concentration, have supported the conclusion of Sanved and determined the value of the dissociation constant of complex cation $[PbC_2H_3O_3]^+$.

In discussing the various theories stated above our observation needs first be mentioned. We started with lead nitrate and ammonium acetate and by thermometric and conductometric measurements at various concentrations have arrived at the definite conclusion that the reaction always takes place in the molecular proportion of 1 : 1, *i.e.*, one molecule of lead nitrate reacts with one molecule of ammonium acetate.

As regards the theory of metathesis due to Noyes and Whitcomb (*loc. cit.*), first objection has been raised by White by pointing out the fact that lead acetate solution is a good solvent for lead chloride where question of metathesis does not arise. Low conductivity of lead acetate has been explained by Blomberg as due to the complex nature of lead acetate itself and not due to its undissociated character. Finally the formation of lead acetate in such a reaction requires that the reaction should take place in a proportion where Pb : $C_2H_3O_2$ is 1 : 2, whereas we have definitely showed that the only reaction that always takes place is in a molecular ratio 1:1. From the facts stated above Noyes and Whitcomb's theory of metathesis in such cases can be discarded altogether.

The hypothesis of White (*loc. cit.*) as to the formation of a complex aceto-plumbite anion also requires that the reaction must take place in a molecular proportion where Pb : $C_2H_3O_2$ is 1 : 2, which is against experimental evidence. The solid compounds that White isolated may not have any appreciable existence in solution.

As regards the third hypothesis due to Sanved (*loc. cit.*) that the solubility of sparingly soluble lead salts in alkali acetates, as to the formation of a cationic complex, has got its support from the work of recent investigators (Edmonds and Birmbaum, *loc. cit.*) already mentioned and also from our own results too. But the work of the above investigators is not free from objection.

In their study of the solubility of lead iodate in varying concentrations of ammonium acetate solution by keeping the ionic strength constant and unimolecular by introducing ammonium perchlorate solution of proper strength, the authors have courted the probability of formation of a series of lead acetato-perchlorates which have been shown to exist in various forms of complex aggregation by Weinland and Stroch, (*Ber.*, 1922, **55B**, 2706). The following lead acetato-perchlorates have been described. The measurements of their conductivities and the comparison of these values with those of binary, tertiary and quaternary electrolytes led Weinland and his school to represent them sa follows :—

(1) $[Pb_3(CH_3COO)_2](ClO_4)_2, H_2O$

(2) $\left[Pb_3(CH_3COO)_4 \right] \begin{matrix} ClO_4 \\ CH_3COO \end{matrix}$

(3) $[Pb_4(CH_3COO)_5](ClO_4)_3, 2H_2O$

(4) $[Pb_2(CH_3COO)_3]ClO_4, 2H_2O$
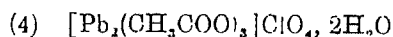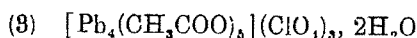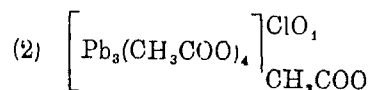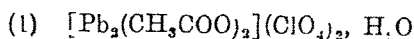
The salts are without exception crystalline and (3) can be crystallised from aqueous solution. Besides these compounds, basic lead-acetato-perchlorates and acetato-perchlorates containing lead in anion (Weinland, *Z. angew. Chem.*, 1921 **34**, 354) have also been described. The following among them are so stable that these can be crystallised from warm water without any decomposition.

(1) $Pb(CH_3COO)_2NaClO_4$

(2) $Pb(CH_3COO)_2NaClO_4, 3H_2O$
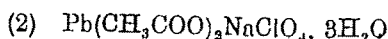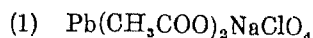
Secondly the solubility of lead iodate in molar ammonium perchlorate (Edmonds and Birnbaum, *loc. cit.*) is about five times its solubility in water and this also forecasts some complex formation which may affect the nature of the reaction and equilibrium constant too.

The third factor which is of importance in the application of solubility in such cases is the effect of the common ion. The common ion may have a two-fold effect. In this case if the reeaction takes place as follows :

$$Pb(IO_3)_2 + NH_4CH_3COO \rightleftharpoons [PbAc]^+ + 2IO_3 + {}^-NH_4{}^+$$
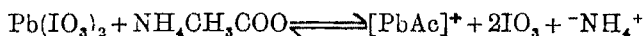
the liberated IO_3 will depress the solubility of lead iodate and further concentration of IO_3 ion may form complex ions like $Pb(IO_3)_3'$; $Pb(IO_3)_4''$ thereby increasing the solubility of $Pb(IO_3)_2$.

Fig. 1

Thermometric titration curves

Fig 2

Conductometric curve
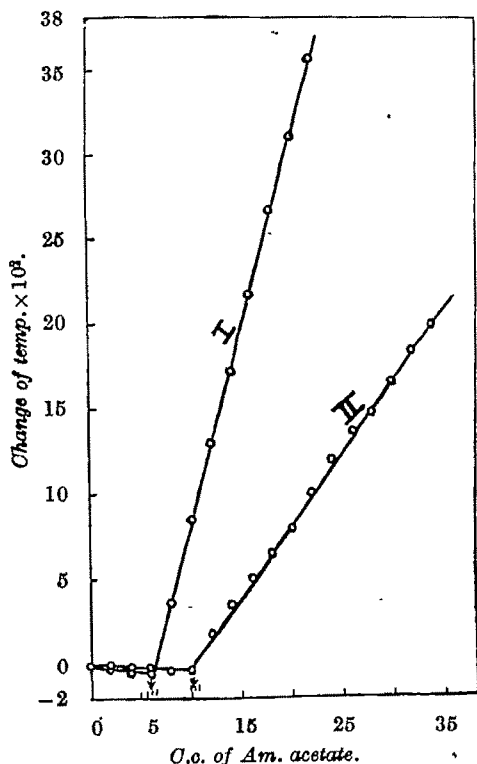
Curves I & II represent respectively, 25 c.c. of $M/2$-Pb(NO$_3$)$_2$, + $2M$ — Am. Ac., and 40 c.c. of $M/4$-Pb(NO$_3$)$_2$ with M — Am. Ac.
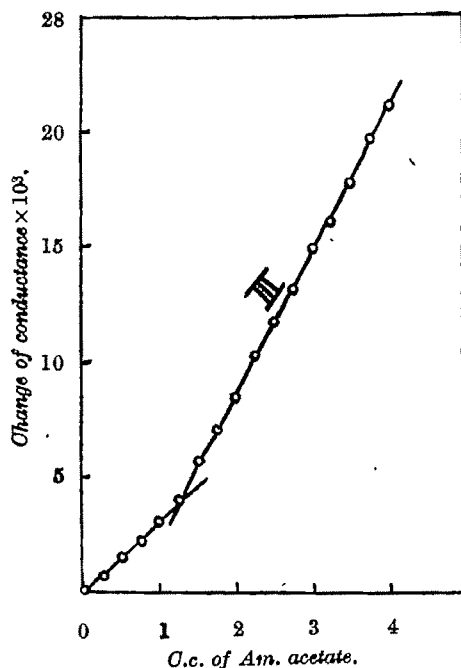
Curve III—75 c.c. of $M/30$-Pb(NO$_3$)$_2$ with $2M$-Am. Ac.

From all the facts stated above question naturally arises that either the solubility curve of Edmonds and Birnbaum (*loc. cit.*) represents a resultant of the opposite effects and does not represent the true state of affairs or the prominent reactions have taken place in a molecular ratio of 1 : 1 by the formation of acetato-iodate and acetato-per-chlorate of Pb and the other ions, either complex or simple, have no appreciable influence

in determining the nature of the curve but may exercise certain influence on the value of the dissociation constant.

Considering all these facts it becomes quite clear that the study of such a complex system in a heterogeneous equilibrium like this may lead to unavoidable errors of serious consequence : on the other hand by following Job's principle of continued variation (*loc. cit.*) in a homogeneous system, a better information and a more correct solution can be arrived at.

EXPERIMENTAL

Materials.—Merck's lead nitrate of reagent quality was recrystallised twice from dilute nitric acid solution. Merck's ammonium acetate of the reagent quality was also used in all measurements.

FIG. 3

Conductometric curve

FIG. 4

Conductometric curve
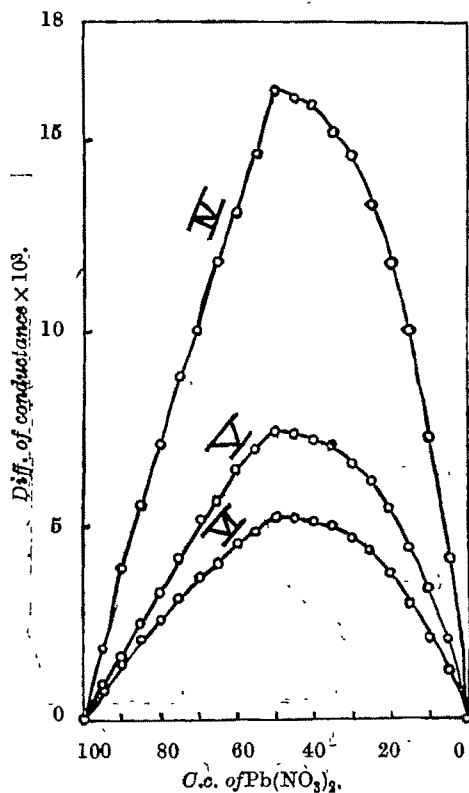
Curves IV—VI represent respectively $M/10$-$Pb(NO_3)_2$+$M/10$-Am. Ac., $M/20$-$Pb(NO_3)_2$+$M/20$-Am. Ac. and $M/30$-$Pb(NO_3)_2$+$M/30$-Am. Ac.
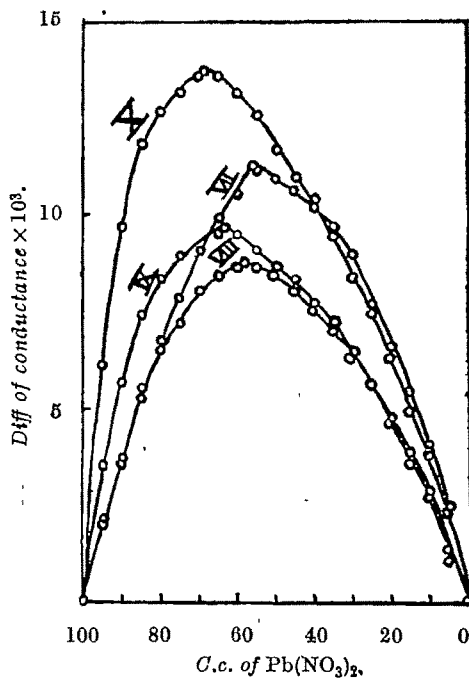
Curves VII—X represent respectively $M/20$-$Pb(NO_3)_2$ & $M/10$-Am. Ac., $M/30$-$Pb(NO_3)_2$ & M·10-Am.Ac., $M/40$-$Pb(NO_3)_2$ & $M/6$-Am. Ac., and $M/30$-$Pb(NO_3)_2$ & $M/3$-Am. Ac.

In thermometric titration lead nitrate solution was taken in a Dewar flask kept within a second Dewar flask. A Beckman thermometer was placed to register temperature. Ammonium acetate solution was then added one c.c. at a time at regular intervals from a burette and changes in temperature were noted after each addition. Stirring, addition

of reagent and observations have been conducted under the conditions laid down by Dutoit (*loc. cit.*). The smooth nature of the curve is indicative of the success of such applications. The change of temperature after each addition has been plotted against respective volumes of ammonium acetate. Curves I and II (Fig. 1) represent the experimental data. The breaks in the curve indicate the proportion in which the complex formation takes place.

The conductivity measurements have been recorded both in equimolecular and non-equimolecular solutions. Conductivity of the individual compounds and also of their mixtures have been measured. The data have been shown in the accompanying tables. The divergence from the additivity rule has been plotted in the curves.

Curve III (Fig. 2) shows conductometric titration results and curves IV-VI (Fig. 3) and curves VII—X (Fig. 4) demonstrate divergence from the additivity rule in equimolar and non-equimolar solutions respectively.

The conductivity apparatus was fitted with thermo-ionic valve amplifiers and so the experimental error in determining resistance was brought within 0.1%. The mean of three values of resistance was always taken. The thermostat was so adjusted that the temperature varied within 0.05°. For each series of measurements to begin with, the platinum electrode was deplatinised and recoated with black deposit of spongy platinum. In consideration of the precautions that have been taken in every step it is clear that the probable error due to all sources cannot exceed 0.2%.

In our investigation reciprocal of the observed resistance *i.e.*, conductance was sufficient to draw the curve. So the cell constant was not determined.

TABLE I

Conductivity experiment of $M/10$-$Pb(NO_3)_2$ and $M/10$-CH_3COONH_4 (Curve IV, Fig. 3)

Temp. = 31.6°.

$M/10$ $Pb(NO_3)_2$ soln. in c.c.	Water added in c.c.	Condy. of (1) $\times 10^3 = C_1$	$M/10$ Am. Ac. soln. in c.c.	Water added in c.c.	Condy. of (2) $\times 10^3 = C_2$	$C_1+C_2=C_3$	$M/10(PbNO_3)_2$ soln. in c.c.	$M/10$ Am. Ac. soln. in c.c.	Condy. of (6)$\times 10^3 = C_4$	C_3-C_4
——(1)——		(2)	——(3)——		(4)	(5)	——(6)——		(7)	(8)
100	0	75.16	0	..	0	75.16	100	0	75.16	0
95	5	72.15	5	95	2.54	74.69	95	5	72.89	1.80
90	10	68.87	10	90	4.98	73.83	90	10	69.93	3.90
85	15	65.79	15	85	7.25	73.04	85	15	67.52	5.52
80	20	63.08	20	80	9.66	72.74	80	20	65.62	7.12
75	25	59.91	25	75	11.92	71.83	75	25	62.96	8.87
70	30	56.37	30	70	14.12	70.49	70	30	60.46	10.03
65	35	53.25	35	65	16.29	69.54	65	35	57.74	11.80
60	40	49.79	40	60	18.59	68.38	60	40	55.30	13.08
55	45	46.86	45	55	20.75	67.61	55	45	53.07	14.54
50	50	43.29	50	50	22.91	66.20	50	50	49.98	16.22
45	55	39.62	55	45	24.83	64.45	45	55	48.40	16.05
40	60	36.37	60	40	26.86	63.23	40	60	47.30	15.93
35	65	32.06	65	35	28.92	60.98	35	65	45.80	15.18
30	70	28.75	70	30	30.91	59.38	30	70	44.82	14.54
25	75	24.23	75	25	33.06	57.29	25	75	44.01	13.28
20	80	19.98	80	20	35.14	55.12	20	80	43.29	11.83
15	85	15.53	85	15	37.30	52.83	15	85	42.76	10.09
10	90	10.86	90	10	39.93	49.97	10	90	42.60	7.37
5	95	5.74	95	5	40.93	46.67	5	95	42.46	4.21
—	—	—	100	0	42.76	—	—	100	42.76	0

TABLE II

Conductivity experiment of $M/20$-$Pb(NO_3)_2$ *and* $M/20$-CH_3COONH_4 (Curve **V**, Fig. 3)

Temp. = 30°.

$M/20$ (PbNO₃)₂ soln. in c.c.	Water added in c.c.	Condy. of $(1) \times 10^3 = C_1$	$M/20$ Am. Ac. soln. in c.c.	Water added in c.c.	Condy. of $(3) \times 10^3 = C_2$	$C_1 + C_2 = C_3$	$M/20$ Pb(NO₃)₂ soln. in c.c.	$M/20$ Am. Ac. soln. in c.c.	Condy. of $(6) \times 10^3 = C_4$	$C_3 - C_4$
(1)		(2)	(3)		(4)	(5)	(6)		(7)	(8)
100	0	40.60	0	—	0	40.60	100	0	40.60	0
95	5	38.80	5	95	1.40	40.20	95	5	39.30	0.90
90	10	37.14	10	90	2.57	39.71	90	10	38.17	1.54
85	15	35.42	15	85	3.71	39.13	85	15	36.68	2.45
80	20	33.72	20	80	4.91	38.63	80	20	35.37	3.26
75	25	32.02	25	75	6.02	38.04	75	25	33.88	4.16
70	30	30.40	30	70	7.09	37.49	70	30	31.54	5.36
65	35	28.57	35	65	8.15	36.72	65	35	31.03	5.69
60	40	26.75	40	60	9.15	36.06	60	40	29.63	6.45
55	45	25.00	45	55	10.37	35.37	55	45	28.37	6.98
50	50	23.07	50	50	11.35	34.42	50	50	26.95	7.47
45	55	21.08	55	45	12.41	33.49	45	55	26.10	7.89
40	60	18.90	60	40	13.50	32.40	40	60	25.16	7.24
35	65	16.96	65	35	14.47	31.43	35	65	24.30	7.13
30	70	14.86	70	30	15.48	30.34	30	70	23.68	6.66
25	75	12.57	75	25	16.46	29.03	25	75	22.83	6.20
20	80	10.30	80	20	17.65	27.95	20	80	22.46	5.49
15	85	7.99	85	15	18.68	26.67	15	85	22.18	4.49
10	90	5.52	90	10	19.66	25.18	10	90	21.75	3.43
5	95	2.92	95	5	20.68	23.60	5	95	21.51	2.09
—	—	—	100	0	21.65	21.65	0	100	21.65	0

TABLE III

Conductivity experiment of $M/30$-$Pb(NO_3)_2$ *and* $M/30$-CH_3COONH_4 (Curve **VI**, Fig. 3)

Temp. = 31.6°.

$M/30$-Pb(NO₃)₂ soln. in c.c.	Water added in c.c.	Condy. of $(1) \times 10^3 = C_1$	$M/30$-Am. Ac. soln. in c.c.	Water added in c.c.	Condy. of $(3) \times 10^3 = C_2$	$C_1 + C_2 = C_3$	$M/30$-Pb(NO₃)₂ soln. in c.c.	$M/30$-Am. Ac. soln. in c.c.	Condy. of $(6) \times 10^3 = C_4$	$C_3 - C_4$
(1)		(2)	(3)		(4)	(5)	(6)		(7)	(8)
100	0	30.32	..	..	..	30.32	100	0	30.32	0
95	5	29.36	5	95	0.92	30.28	95	5	29.51	0.77
90	10	27.96	10	90	1.77	29.73	90	10	28.30	1.43
85	15	26.53	15	85	2.60	29.13	85	15	27.06	2.07
80	20	25.30	20	80	3.39	28.69	80	20	26.10	2.59
75	25	23.84	25	75	4.23	28.07	75	25	24.93	3.14
70	30	22.49	30	70	5.02	27.51	70	30	23.84	3.67
65	35	21.22	35	65	5.85	27.07	65	35	23.00	4.07
60	40	19.78	40	60	6.65	26.43	60	40	21.83	4.60
55	45	18.32	45	55	7.44	25.76	55	45	20.88	4.88
50	50	16.82	50	50	8.24	25.06	50	50	19.78	5.28
45	55	15.34	55	45	9.05	24.30	45	55	19.18	5.21
40	60	13.28	60	40	9.76	23.04	40	60	18.46	5.18
35	65	12.27	65	35	10.49	22.76	35	65	17.72	5.04
30	70	10.76	70	30	11.30	22.06	30	70	17.32	4.74
25	75	9.14	75	25	12.02	21.16	25	75	16.68	4.48
20	80	7.48	80	20	12.75	20.23	20	80	16.45	3.78
15	85	5.73	85	15	13.49	19.17	15	85	16.16	3.01
10	90	3.94	90	10	14.19	18.13	10	90	15.96	2.17
5	95	1.00	95	5	14.97	17.07	5	95	15.77	1.30
..	..	0	100	0	15.84	15.84	0	100	15.84	0

TABLE IV

Conductivity experiment of $M/20$-$Pb(NO_3)_2$ and $M/10$-CH_3COONH_4 (Curve VII, Fig. 4)

Temp.$=30°$

$M/20$ $Pb(NO_3)_2$ soln. in c.c.	Water added in c.c.	Condy. of (1)$\times10^3=C_1$	$M/10$-Am. Ac. soln. in c.c.	Water added in c.c.	Condy. of (3)$\times10^3=C_2$	$C_1+C_2=C_3$	Water added in c.c.	$M/10$-Am. Ac. soln. in c.c.	Condy. of (6)$\times10^3=C_4$	C_3-C_4
(1)		(2)	(3)		(4)	(5)	(6)		(7)	(8)
100	0	40.60	..	..	..	40.60	100	0	40.60	0
95	5	38.80	5	95	2.52	41.32	95	5	39.34	1.98
90	10	37.14	10	90	4.79	41.93	90	10	38.39	3.54
85	15	35.52	15	85	7.05	42.57	85	15	37.30	5.27
80	20	33.68	20	80	9.25	42.93	80	20	36.15	6.78
75	25	31.98	25	75	11.44	43.42	75	25	35.57	7.85
70	30	30.28	30	70	13.62	43.90	70	30	34.83	9.07
65	35	28.53	35	65	15.65	44.18	65	35	34.28	9.90
60	40	26.68	40	60	17.74	44.42	60	40	33.89	10.53
56	44	25.34	44	56	19.40	44.74	56	44	33.50	11.24
55	45	24.93	45	55	19.78	44.71	55	45	33.59	11.12
50	50	22.99	50	50	21.78	44.77	50	50	33.82	10.95
45	55	20.99	55	45	23.84	44.83	45	55	34.16	10.67
40	60	18.80	60	40	25.74	44.54	40	60	34.34	10.20
35	65	16.85	65	35	27.84	44.69	35	65	35.02	9.67
30	70	14.77	70	30	29.87	44.64	30	70	35.66	8.98
25	75	12.47	75	25	31.80	44.27	25	75	36.59	7.68
20	80	10.30	80	20	33.77	44.07	20	80	37.49	6.58
15	85	7.98	85	15	35.70	43.68	15	85	38.23	5.48
10	90	5.52	90	10	37.77	43.29	10	90	39.22	4.07
5	95	2.92	95	5	39.62	42.54	5	95	40.20	2.34
..	..	..	100	0	41.60	41.60	..	100	41.60	0

TABLE V

Conductivity experiment of $M/30$-$Pb(NO_3)_2$ and $M/10$-CH_3COONH_4 (Curve VIII, Fig. 4)

Temp.$=30°$

$M/30$-$Pb(NO_3)_2$ soln. in c.c.	Water added in c.c.	Condy. of (1)$\times10^3=C_1$	$M/10$-Am. Ac. soln. in c.c.	Water added in c.c.	Condy. of (3)$\times10^3=C_2$	$C_1+C_2=C_3$	$M/30$-$Pb(NO_2)_2$ soln. in c.c.	$M/10$-Am. Ac. soln. in c.c.	Condy. of (6)$\times10^3=C_4$	C_3-C_4
(1)		(2)	(3)		(4)	(5)	(6)		(7)	(8)
100	0	29.11	..	..	..	29.11	100	0	29.11	0
95	5	27.97	5	95	2.52	30.49	95	5	28.41	2.08
90	10	26.64	10	90	4.79	31.63	90	10	27.95	3.68
85	15	25.68	15	85	7.11	32.79	85	15	27.28	5.51
80	20	24.13	20	80	9.36	33.49	80	20	26.99	6.50
75	25	22.80	25	75	11.50	34.30	75	25	27.10	7.20
70	30	21.57	30	70	13.69	35.26	70	30	27.17	8.09
65	35	20.14	35	65	15 71	35.85	65	35	27.43	8.42
60	40	18.78	40	60	17.93	36.71	60	40	28.07	8.64
58	42	18.33	42	58	18.71	37.04	58	42	28.30	8.74
55	45	17.50	45	55	19.87	37.37	55	45	28.76	8.61
50	50	16.09	50	50	21.93	38.02	50	50	29.55	8.47
45	55	14.64	55	45	23.94	38.58	45	55	30.52	8.06
40	60	13.19	60	40	25.99	39.18	40	60	31.60	7.58
35	65	11.78	65	35	27.95	39 73	35	65	32.64	7.09
30	70	10.24	70	30	29.99	40.23	30	70	33.72	6.51
25	75	8.60	75	25	31.98	40.67	25	75	35.04	5.63
20	80	7.12	80	20	33.87	40.99	20	80	36.24	4.75
15	85	5.47	85	15	35.96	41.43	15	85	37.59	3.84
10	90	3.76	90	10	37.87	41.63	10	90	38.80	2.83
5	95	2.00	95	5	39.62	41.62	5	95	40.27	1.35
..	..	..	100	..	41.67	41.67	..	100	41.67	0

TABLE VI

Conductivity experiment of $M/40$-$Pb(NO_3)_2$ *and* $M/6$-CH_3COONH_4 *(Curve IX, Fig. 4)*

Temp. $= 30°$

$M/40$-$Pb(NO_3)_2$ soln. in c.c.	Water added in c.c.	Condy. of (1)$\times10^3=C_1$	$M/6$-Am. Ac. soln. in c.c.	Water added in c.c.	Condy. of (3)$\times10^3=C_2$	$C_1+C_2=C_3$	$M/40$-$Pb(NO_3)_2$ soln. in c.c.	$M/6$-Am. Ac. soln. in c.c.	Condy. of (6)$\times10^3=C_4$	C_3-C_4
(1)		(2)	(3)		(4)	(5)	(6)		(7)	(8)
100	..	23.35	..	..	..	23.35	100	..	22.35	0
95	5	22.36	5	95	4.25	26.61	95	5	23.12	3.49
90	10	21.40	10	90	7.99	29.39	90	10	23.74	5.65
85	15	20.38	15	85	11.74	32.12	85	15	24.73	7.39
80	20	19.34	20	80	15.46	34.80	80	20	26.44	8.31
75	25	18.33	25	75	19.03	37.36	75	25	28.41	8.95
70	30	17.23	30	70	22.57	39.80	70	30	30.64	9.16
65	35	16.09	35	65	26.10	42.19	65	35	32.67	9.52
64	36	15.90	36	64	26.77	42.67	64	36	33.04	9.63
60	40	15.07	40	60	29.45	44.52	60	40	35.01	9.45
55	45	14.05	45	55	32.78	46.83	55	45	37.75	9.08
50	50	12.83	50	50	36.10	48.93	50	50	40.27	8.66
45	55	11.70	55	45	39.45	51.15	45	55	42.78	8.37
40	60	10.58	60	40	42.60	53.18	40	60	45.43	7.75
35	65	9.40	65	35	45.85	55.28	35	65	47.96	7.29
30	70	8.14	70	30	48.81	56.95	30	70	50.52	6.43
25	75	6.90	75	25	51.96	58.80	25	75	53.16	5.64
20	80	5.62	80	20	55.33	60.95	20	80	56.30	4.65
15	85	4.33	85	15	58.25	62.58	15	85	58.99	3.59
10	90	2.96	90	10	61.89	64.54	10	90	61.89	2.70
5	95	1.57	95	5	63.89	65.64	5	95	64.44	1.02
..	..	..	100	..	66.82	66.82	..	100	66.82	0

TABLE VII

Conductivity experiment of $M/30$-$Pb(NO_3)_2$ *and* $M/3$-CH_3COONH_4 *(Curve X, Fig. 4)*

Temp. $= 30°$

$M/30$-$Pb(NO_3)_2$ soln. in c.c.	Water added in c.c.	Condy. of (1)$\times10^3=C_1$	$M/3$-Am. Ac. soln. in c.c.	Water added in c.c.	Condy. of (3)$\times10^3=C_2$	$C_1+C_2=C_3$	$M/3$-$Pb(NO_3)_2$ sol. . . c.	$M/3$-Am. Ac. soln. in c.c.	Condy. of (6)$\times10^3=C_4$	C_3-C_4
(1)		(2)	(3)		(4)	(5)	(6)		(7)	(8)
100	..	29.23	..	..	..	29.23	100	..	29.23	0
95	5	28.07	5	95	8.02	36.09	95	5	29.99	6.10
90	10	26.95	10	90	15.25	42.20	90	10	32.51	9.69
85	15	25.78	15	85	22.19	47.97	85	15	36.15	11.82
80	20	24.31	20	80	28.76	53.07	80	20	40.42	12.65
75	25	22.90	25	75	35.29	58.19	75	25	45.05	13.14
70	30	21.66	30	70	41.73	63.39	70	30	49.83	13.56
69	31	21.40	31	69	43.29	64.69	69	31	51.02	13.67
65	35	20.22	35	65	47.91	68.13	65	35	54.61	13.52
60	40	18.86	40	60	54.24	73.01	60	40	59.91	13.10
55	45	17.60	45	55	60.24	77.84	55	45	65.28	12.56
50	50	16.25	50	50	65.54	81.79	50	50	70.13	11.66
45	55	14.70	55	45	72.03	86.73	45	55	75.82	10.91
40	60	13.27	60	40	77.94	91.21	40	60	80.86	10.35
35	65	11.87	65	35	83.26	95.13	35	65	85.99	9.14
30	70	10.37	70	30	88.91	99.28	30	70	90.91	8.37
25	75	8.76	75	25	94.20	102.96	25	75	95.52	7.44
20	80	7.14	80	20	98.96	106.10	20	80	99.80	6.30
15	85	5.54	85	15	104.90	110.44	15	85	105.50	4.94
10	90	3.79	90	10	110.30	114.09	10	90	110.30	3.79
5	95	2.02	95	5	115.50	117.52	5	95	115.10	2.42
..	..	..	100	..	119.60	119.60	..	100	119.60	0

Calculation of the Value of the Dissociation Constant K.

The general equation relating the value of the dissociation constant K as derived by Job is as follows :—

$$\frac{c^{m+n+1} \times p^{n-1}[(pm+n)x-n]^{m+n}}{m^{n-1}.n^{n-1}.(p-1)^{m+n-1} \times [n-(m+n)x]} \qquad \dots \quad (i)$$

where m represents mols of one of the components say A

n represents mols of the other component say B

c, the molar concentration of A

$pc \qquad .. \qquad .. \qquad$ B

x c.c. of B combining with $(1-x)$ c.c of A to give the maximum changing effect. Putting $p=1$ in equation (i) *i.e.*, in the case of equimolecular solutions we have

$$m/n = \frac{1-x}{x} \qquad \dots \quad (ii)$$

With reference to thermometric curves I and II (Fig. 1), conductometric titration curve III (Fig. 2) and conductometric measurement curves IV, V and VI (Fig. 3) showing divergence from the additivity rule due to complex formation in equimolecular mixtures, it is evident that one mole of lead nitrate reacts with one mole of ammonium acetate *i.e.*, $1-x/x=1$ So m and n in equation (ii) have identical values   *i.e.*, $m=n=1$; putting this value of m and n in the general equation (i) we get the following

$$K = \frac{\{c(p+1)x-1\}^2}{(p-1)(1-2x)} \qquad \dots \quad (iii)$$

whence the following values of K has been calculated.

From molar concentrations the values of c and p have been worked out by knowing the values of α , the degree of dissociation of the two salts in the dilutions concerned. Results are tabulated below.

TABLE VIII

Table No.	Fig. No.	Curve No.	c	p	x	$k \times 10^3$	Mean $k \times 10^3$
4	4	VII	0.03718	2.206	0.44	43.18	40.76
5	4	VIII	0.02635	3.112	0.42	41.21	
6	4	IX	0.02035	6.600	0.36	39.10	
7	4	X	0.02635	9.232	0.31	39.77	

DISCUSSION

In reviewing the works of the previous investigations it has been clearly pointed out that no direct or definite evidence as regards the existence of acetato complex of lead was arrived at. The indirect evidence based upon the measurements of solubility was the only source of information. The solubility determination in such cases also meets with adverse circumstances. Even the most recent investigation of Edmonds and Birnbaum is based upon the assumptions that

(*i*) Wieland's higher lead-acetato perchlorates do not exist in solution to any appreciable extent. (*ii*) No acetato-plumbite ion is formed. (*iii*) Probability of hydrolysis and, basic salt formation is negligible. (*iv*) The effect of IO_3' ion liberated in the reaction

2—1607P—2

in depressing the solubility has been counterbalanced by the formation of an anionic complex which increases the solubility. (v) Neither lead perchlorato-iodate nor lead perchlorate is formed in solution.

In our investigation, however, direct and definite evidence as regards the formation of a lead-acetato $[PbC_2H_3O_2]^{\cdot}$ cation has been put foward The two physicochemical measurements, namely (a) conductivity and (b) thermal effect, we adopted, are independent of each other as regards principle. The former depends on colligative property and the latter serves as an index to chemical reaction only. Combining these two methods we have been able to study the reaction within wide range of concentrations. The nature of the curves shows it definitely that one and only one compound is formed in all dilutions. The constant value of the dissociation constant in varying concentrations proves it definitely that the only complex formed in solution is the lead-acetato cation $[PbC_2H_3O_2].^{+}$ Though the lead-acetato nitrate has not yet been isolated yet the isolation of the compounds like $\diagdown\diagup\,{}^{n}_{C_2H_3O_2}$ where n stands for Cl, Br, I or ClO_4 proves the existence of such complex compound in solid state as well. The mean value of the dissociation constant deduced from our measurements is 40.76×10^{-3} at $30°$, whereas the dissociation constant from the solubility measurement of Edmonds and Birnbaum is 9.65×10^{-3} at $25°$ and such a divergence cannot be attributed to difference in temperature alone. It may be rather due to the disturbing effects already pointed out in the determination of solubility in such cases under such conditions.

In conclusion the authors wish to express their thanks to Dr. P. B. Sarkar for helpful suggestions and laboratory facilities.

ISOLATION OF XANTHYLETIN FROM THE BARK OF *CITRUS ACIDA*, ROXB.

By (Miss) Asima Mookerjee

Xanthyletin, a 2 : 2-dimethylchromeno-coumarin, m.p. 131.5°, has been isolated from the bark of *Citrus acida*, Roxb.

Citrus acida, Roxb. is a variety of *Citrus medica* (*Iconum Botanicarum, Index Londinensis*, 1930, **2**, 224, 225) and it belongs to the family *Rutaceae*. The plant is highly valued in therapeutics for its antiscorbutic properties and it is very rich in essential oils which are strongly carminative and stomachic.

From the bark of *Citrus acida*, Roxb. which was collected from Darjeeling, a neutral crystalline compound, m.p. 131.5° has been isolated in a yield of 0.25 per cent. The compound is neutral towards litmus and indifferent towards ferric chloride. It shows no optical activity and dissolves in concentrated sulphuric acid with an orange solution. It is insoluble in 1% aqueous potassium hydroxide, but dissolves in alcoholic alkali, which turns yellow. The solution on dilution remains clear but on acidification precipitates the original substance. These properties indicate that the substance is a coumarin. The C-H values of the compound are found to agree with the formula $C_{14}H_{12}O_3$. The compound does not contain any methoxy group and does not produce acetyl derivative with acetic anhydride, nor does it form a semicarbazone or phenylhydrazone thus showing the absence of —OH and —CO— groups. These properties of the compound as also the analyses of the substance indicate close agreement with those of xanthyletin (I) which has been isolated so far only from two different *Rutaceous* plants, namely, *Xanthoxylum americanum*, Mill (Robertson and Subramanium, *J. Chem. Soc.*, 1937, 286; Bell and Robertson, *ibid.*, 1936, 1828; Dieterle and Kruta, *Arch. Pharm.*, 1937, **275**, 45) and *Luvanga scandens*, Ham (Bose and Mookerjee, *J. Indian Chem. Soc.*, 1944, **21**, 281; Späth, Bose, Dobrovolny and Mookerjee, *Ber.*, 1939, **72**, 1450; 1940, **73**, 1361). A direct comparison of the substance with xanthyletin isolated from *L. scandens* (*vide supra*) has been made. It is found that the physical properties of the two compounds are identical and a mixture of the two melts also at 131.5° and gives similar colour reactions with concentrated sulphuric acid.

The tetrahydro derivative of the substance has the same m.p. (158.5°) as tetrahydro-xanthyletin, and both of them show no depression in their mixed melting point. Thus the coumarin of *Citrus acida* is identical with xanthyletin (I).

(I)
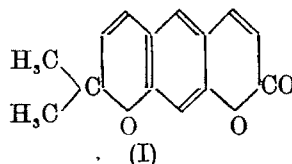
EXPERIMENTAL

Isolation of Xanthyletin.—Sun-dried bark (800 g.) of *C. acida* was crushed in a mortar and sieved. The fine powder, thus prepared, was soxhletted with ether (1.5 litres) during

24 hours. The green ethereal extract was concentrated to 30 c.c. and kept in a frigidaire for about a month. The crystals (1.00 g.), m.p. 129.5°, were collected and rapidly washed with ether and the filtrate was further worked up for coumarins by the method of Späth and Socias (*Ber.*, 1934, **67**, 59).

The filtrate was freed from the solvent and the oil obtained (50 g.) was cooled to about 20° and to it was added 50 c.c. of 20% methyl alcoholic potassium hydroxide with constant shaking. The mixture was allowed to stand for 45 minutes at the same temperature and then poured into 250 c.c. of ice-water. The mixture was extracted 5 times with ether. The reddish brown aqueous solution was acidified with hydrochloric acid (Congo-red) and allowed to stand overnight. Next morning, the greater portion of methyl alcohol was removed under reduced pressure, then cooled and thrice extracted with ether (100 c.c.). The reddish brown ethereal extract was twice washed with 20 c.c. of 25% potassium carbonate solution and then with water. The ethereal digest was dried over anhydrous sodium sulphate and distilled. The residue solidified on keeping in an ice-chest for a few days. This was washed with a little ether and dried over a porous tile to remove adhering oil. This had m.p. 129.5° (1 g.).

The two crude fractions (*vide supra*) were mixed together and crystallised from alcohol, when colourless plates, m.p. 131.5°, were obtained. On further crystallisation from alcohol, acetone and benzene there was no change in m.p. Further distillation in *vacuo* at 140-45°/0.1 mm. the melting point could not be raised. (Found in a sample dried in *vacuo* over P_2O_5 for 3 hours at 90° : C, 74.12 ; H, 5.4. $C_{14}H_{12}O_3$ requires C, 73.7 ; H, 5.3 per cent).

Action of Dilute Alkali on Xanthyletin.—The substance (0.1 g.) in pure methyl alcohol (5 c.c.) was mixed with aqueous potassium hydroxide (40 c.c.) and the solution was refluxed on the water-bath for 1 hour. The yellow solution gradually turned brown. It was acidified with hydrochloric acid (congo-red), kept overnight and extracted with ether next morning. The residue obtained from the ethereal extract crystallised from alcohol in plates, m.p. 131.5° and no change in m.p. was noticed when mixed with the starting compound.

Catalytic Hydrogenation of Xanthyletin.—The substance (0.2 g.) was dissolved in glacial acetic acid (5 c.c.) and was shaken in an atmosphere of hydrogen with platinum oxide catalyst (0.1 g.). Hydrogen absorbed was found to be 42.9 c.c. at 27° and 762 mm. $C_{14}H_{12}O_3$ requires 42.74 c.c. at 27° and 762 mm.

The solution was filtered off from the catalyst, freed from the solvent and the residue was crystallised from alcohol. Colourless rhombic plates separated, which melted at 158.5° and showed no depression in m.p. when mixed with tetrahydroxanthyletin which melted alone at 158.5°.

The author wishes to offer her thanks to Dr. P. K. Bose for his kind interest in the work.

ACTION OF BROMINE ON OXYMETHYLENE *CYCLO*HEXANONE : FORMATION OF α-BROMO-β-KETO-ALDEHYDE (1-*CYCLO*HEXANONE-2-BROMO-2-ALDEHYDE)

BY A. S. MEHTA, R. KAUSHAL AND S. S. DESHAPANDE

By the action of bromine on oxymethylene-*cyclo*hexanone α-bromo-β-ketoaldehyde (1-*cyclo*-hexanone-2-bromo-2-aldehyde) has been formed. Evidence is advanced in favour of Kurt Meyer's hypothesis of alcoholic bromine addition for the estimation of keto-enolic mixtures.

In a keto-enolic equilibrium mixture a chemical method for the estimation of enols is suggested by Meyer (*Annalen*, 1911, 380, 212 ; *Ber.*, 1911, 44, 2718 ; 1912, 45, 2843). It consists in adding alcoholic solution of bromine to the mixture. The enol rapidly absorbs bromine forming an unstable dibromide which immediately gives off hydrobromic acid and produces a bromoketone. From the amount of bromine absorbed, the quantity of the enol in the mixture is found out as the keto form does not absorb bromine. Thus in the case of acetoacetic ester the reactions are as follows :

$$CH_3.C(OH)=CH.COOEt + Br_2 \rightarrow CH_3\underset{\underset{Br}{|}}{C}(OH).\underset{\underset{Br}{|}}{C}H.COOEt \xrightarrow{-HBr} CH_3.CO.CHBr.COOEt$$

(I)
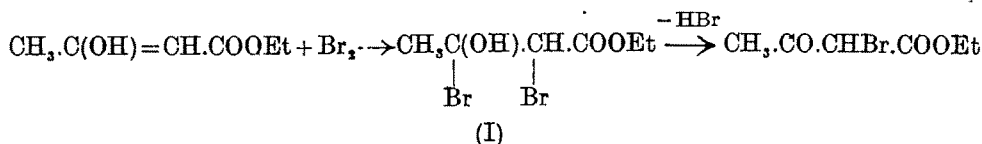
The above cannot be a method for the preparation of bromoacetoacetic ester (I) as according to Meyer himself the enol is only 7% in the ordinary acetoacetic ester. Yet bromoacetoacetic ester is prepared by the action of bromine on acetoacetic ester mixed with ice-water (Conrod and Schmidt, *Ber.*, 1896, 29, 1044) and it is not clear whether the mechanism of bromintion is in this case the same as assumed by Meyer or it is a mere case of bromination by substitution. If, however, bromine and acetoacetic ester are made to react at 0° in carbon tetrachloride in place of ice-water, γ-bromoacetoacetic ester results. Here obviously, the action of bromine on the ester cannot be on the line suggested by Meyer.

Another keto-enolic system, where halogenation has been studied, is afforded by 1 : 3-diketones (II). Thus by the action of bromine on dibenzoylmethane (II, R=R′=Ph) Neufille and Pechmann (*Ber.*, 1890, 23, 3377) obtained bromodibenzoylmethane (III, R=R′=Ph ; X=Br).

$$R.CO.CH_2.CO.R′ \qquad R.CO.CHX.CO.R′$$
$$\text{(II)} \qquad\qquad\qquad \text{(III)}$$

$$R.CO.CH_2.R′ \rightarrow R.CO.CHR′.CHO \rightleftharpoons R.CO.CR′=CH.OH$$
$$\text{(IV)} \qquad\qquad\qquad \text{(V)}$$
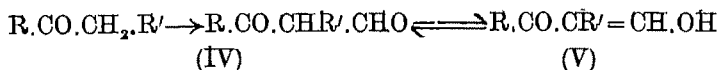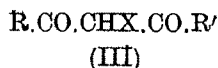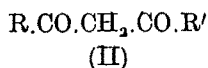
It is not clear whether the bromination is effected by addition or by mere substitution. In the case of acetylacetone (II, R=R′=CH₃) no bromo compound is described. Combes (*Compt. rend.*, 1890, 111, 273), however, prepared chloroacetylacetone (III, R=R′=CH₃ ; X=Cl) by the action of sulphuryl chloride on acetylacetone.

The β-ketoaldehydes (IV) which are really formyl derivatives of a ketone belong to the general class of 1 : 3-dicarbonyl compounds (II) like the β-ketonic esters or the

β-diketones. Claisen has shown that β-ketoaldehydes (IV) exist mostly as their enols of oxymethylene ketones (V).

It is clear that an excellent means of testing Kurt Meyer's hypothesis would be to observe the action of bromine on oxymethylene ketones (V). Some of the oxymethylene ketones are quite unstable and in an attempt to isolate them in pure condition they undergo self-condensation and change into trisubstituted benzenes (Claisen and Stylos, *Ber.*, 1888, **21**, 1145). Hence oxymethylene *cyclo*hexanone (VI), which cannot undergo self-condensation, was selected for the test (*cf.* also Kaushal, Sovani and Deshapande, *J. Indian Chem. Soc.*, 1942, **19**, 107).
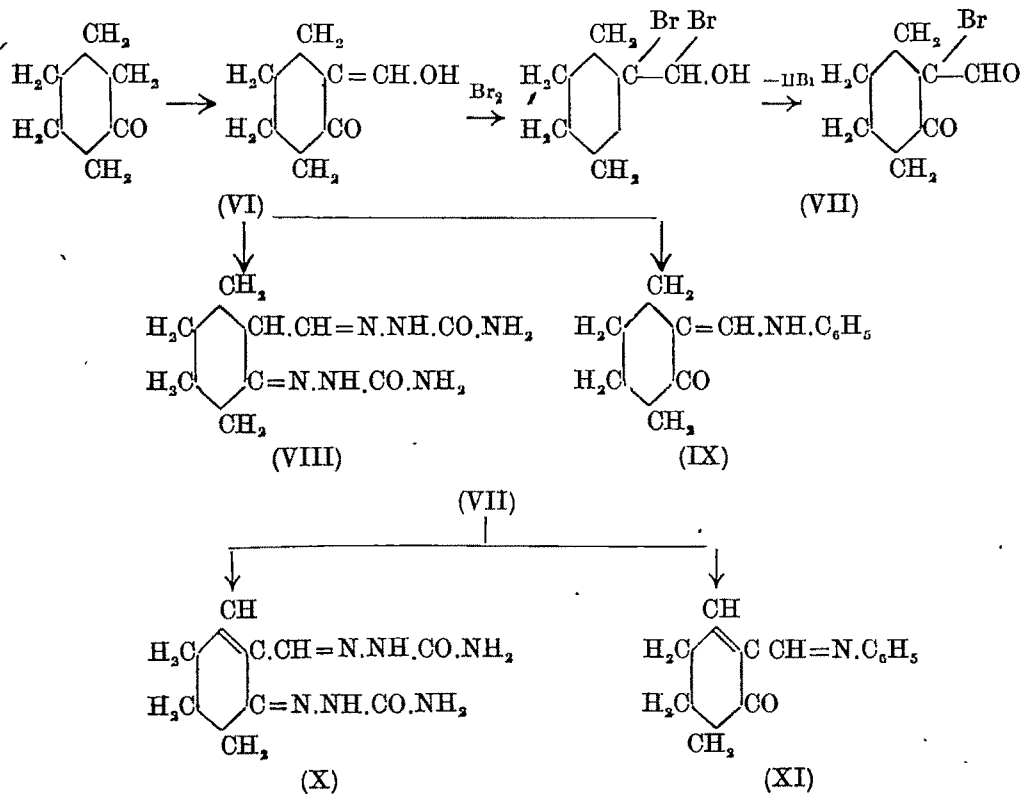
When pure oxymethylene *cyclo*hexanone is dissolved in a mixture of dry ether and carbon tetrachloride and to this at 0° bromine, dissolved in carbon tetrachloride, is gradually added, the latter is rapidly absorbed. A sticky semi-solid substance gradually separates.When the reaction is carried out in dry pure ether only, the quality of the reaction product improves and also the yield. The product is grey and somewhat brown. After the addition of bromine is complete and the reaction mixture is still at 0° and when the hydrobromic acid slowly begins to come out, the mixture is quickly filtered and the grey solid quickly washed with dry ether. The evolution of hydrobromic acid continues and the product is dried on a porous plate in a calcium chloride desiccator. The solid is unstable and cannot be preserved. It can keep under dry ether for sometime but afterwards begins to change into a dark coloured liquid. Purified by washing it has been analysed

and the results of analysis indicate that it is α-bromo-β-ketoaldehyde (VII) formed obviously by the addition of bromine to the enol (VI) followed by loss of hydrobromic acid. At each of the stages (*i*) absorption of bromine and (*ii*) loss of hydrobromic acid have been separately observed and as the second stage follows a few minutes after the first, this affords a strong evidence in favour of Kurt Meyer's hypothesis.

That (VII) is an aldehyde readily follows from the observations that it reduces Fehling's solution and with ammoniacal silver nitrate it gives a silver mirror with some precipitate of silver bromide. Similar behaviour is shown by α-bromopropionic aldehyde (Franke, *Annalen*, 1907, **351**, 423). The aldehyde (VII) forms a disemicarbazone losing at the same time a molecule of hydrobromic acid which is taken up by the base semicarbazide. The semicarbazone has therefore the structure (X). This semicarbazone (X) differs from the semicarbazone (VIII) of the original oxymethylene *cyclo*hexanone both in its melting point and composition. Moreover, (X) readily absorbs large volumes of bromine water while (VIII) does so only very slowly

The bromo-aldehyde (VII) also condenses with aniline to form an anil, m.p. 142° containing no bromine. Here also hydrobromic acid seems to have been removed by aniline and the anil formed has the structure (XI). The oxymethylene *cyclo*hexanone, however, forms an anilide (IX) m.p. 169°.

From the above results it seems that by the action of bromine on oxymethylene *cyclo*hexanone, the α-bromo-β-ketoaldehyde (VII) has been synthesised, which is unstable.

<div align="center">E X P E R I M E N T A L</div>

Oxymethylene cyclohexanone (VI) was prepared by Claisen's method using for one molecule *cyclo*hexanone 1.25 mols. of ethyl formate and 1.25 atoms of sodium wire in dry ether under ice-cooling. On working the sodium compound thus formed, crude oxymethylene *cyclo*hexanone was obtained as orange coloured liquid which passed over as almost colourless liquid at 79°/4 mm. 14 G. *cyclo*hexanone gave 11 g. pure oxymethylene *cyclo*hexanone (*cf.* Wallach, *Annalen*, 1903, **329**, 109). It is volatile in steam and with acids on heating gives highly coloured solution and with ferric chloride produces intense violet colour.

The disemicarbazone (VIII) of oxymethylene *cyclo*hexanone, prepared as usual, separated as white crystalline mass. It was dried and recrystallised from water, m.p. 231° (decomp.). (Found in the material dried at 120° for two hours : N, 34.7. $C_9H_{16}O_2N_6$ requires N, 35.0 per cent.)

The oxymethylene cyclohexanone anilide (IX) was prepared on mixing oxymethylene *cyclo*hexanone and aniline separately dissolved in ether, when heat was evolved and a solid began to separate. It was cooled and allowed to remain for sometime. The yellow compound was filtered, washed, dried and recrystallised from absolute alcohol as long, thick, star-shaped needles, m.p. 169°. (Found : N, 7.2, 6.8. $C_{13}H_{15}ON$ requires N, 6.9 per cent).

Action of Bromine on Oxymethylene cyclohexanone : *Formation of* (VII).—Oxymethylene *cyclo*hexanone (1 part) was dissolved in dry ether (3 parts) and the mixture well cooled in ice. Well cooled ether solution of bromine was slowly added in instalments.

On shaking a yellowish grey solid separated which began losing hydrobromic acid. A little more bromine was added until the supernatant liquid acquired a pale yellow colour. It was well shaken and allowed to remain in ice for 5 minutes and then quickly filtered at the pump and washed well with dry ether. It was dried in a calcium chloride desiccator. 2.5 G. oxymethylene *cyclo*hexanone gave 2 g. of the bromo-aldehyde. It could not be crystallised, purified by washing with dry ether it melted at 88-90°. (Found : C, 39.9 ; H, 5.0 ; Br, 39.6. $C_7H_9O_2Br$ requires C, 40.9 ; H, 4.4 ; Br, 39.0 per cent).

The product is unstable and on exposure it changes into a dark coloured liquid. With water, alcohol or other solvents it passes into a dark coloured liquid. It reduces Fehling's solution and ammoniacal silver nitrate.

Action of Semicarbazide on the Bromo-aldehyde (VII) : *Formation of the Disemicarbazone* (X).—A little of the bromo-aldehyde was added to a solution of semicarbazide hydrochloride and sodium acetate when it went into solution giving a yellow colour. On shaking and scratching the semicarbazone separated as yellowish white solid which was filtered, washed, dried and recrystallised from dilute alcohol and dried at 120°, m.p. 190°. (Found : N, 34.8. $C_9H_{14}O_2N_6$ requires N, 35.3 per cent.) It takes up readily large amounts of bromine water.

Action of Aniline on the Bromo-aldehyde (VII) : *Formation of Anil* (XI).—To 1 g. of the bromo-aldehyde aniline was added in drops and the whole mixed well. Condensation with aniline took place with evolution of heat. The crude product on crystallisation from alcohol separated as brownish thick prisms melting at 142° and was found to contain no bromine, yield 0.5 g. (Found : N, 7.3. $C_{13}H_{13}ON$ requires N, 7.0 per cent).

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SIDE-CHAIN CHLORINATION OF AROMATIC COMPOUNDS IN THE VAPOUR PHASE

BY G. V. ASOLKAR AND P. C. GUHA

According to the literature, the ethoxy- and methoxy-benzyl chlorides are prepared by the action of phosphorus trichloride or thionyl chloride on the corresponding alcohols. Ethyl and methyl ethers of *ortho-*, *meta-* and *para-*cresols on chlorination in the vapour phase have yielded these chlorides, the yield in the case of the *ortho*-compound being 60-65%, the *meta* and *para* compounds furnishing 25% and 30% respectively. *Ortho-*, *meta-* and *para*-xylenes yield 50-60% of the corresponding xylyl chlorides. The chloro derivatives of anisole and cineol were obtained for the first time by the vapour phase chlorinations. Sunlight favours these side-chain chlorinations. The vapour phase chlorination of *ortho-*, *meta-* and *para-* nitrotoluenes was not successful, although these chlorinations are known to proceed well in the liquid phase.

In the chlorination of toluene, substitution may take place either in the nucleus or in the methyl group. Nuclear substitution takes place when the halogen acts on toluene in presence of iodine or other halogen carriers. Side-chain substitution occurs when the halogen acts on boiling toluene or in presence of direct sunlight, the influence of light being greater than that of heat in inducing substitution in the side-chain (Cohen, Dawson, Blockley and Woodmansey, *J. Chem. Soc.*, 1910, **97**, 1623 ; Bancroft, *J. Phys. Chem.*, 1908, **12**, 240, 417). The side-chain chlorinated derivatives of aromatic hydrocarbons, particularly those of toluene, are of great technical importance.

Vapour phase chlorination of toluene has been studied by Mason *et al* (*J. Chem. Soc.*, 1931, 3150) in which chlorine reacts smoothly with an excess of toluene vapours at temperatures above 250° in the absence of specific chlorine carriers, the products being chiefly benzyl and benzal chlorides. The preparation of the side-chain halogen substitution products of toluene has been effected by Gibbs and Geiger (*U. S. patent*, 12,46,739, 1917) in the vapour phase, in the presence of ultraviolet light. Generally substitution in the side-chain is favoured at higher temperature ; whilst in the presence of a catalyst or a halogen carrier, the replacement of nuclear hydrogen takes place at a lower temperature.

A survey of the literature revealed that the vapour phase chlorination of the methyl cresyl ethers has not been done. The principle of the vapur phase chlorination of toluene as indicated above has now been extended for the methyl and ethyl cresyl ethers, xylols, nitrotoluenes and some other aromatic compounds, to get the corresponding side-chain substituted halides. In the present investigation, these side-chain substituted chlorides have been obtained by chlorinating cresyl ethers in the vapour phase instead of the usual method of obtaining them in the liquid phase by the use of phosphorus oxychloride or thionyl chloride on the corresponding alcohols (Pschorr, *Ber.*, 1900, **33**, 165 ; *Annalen*, 1912, **391**, 44 ; Königs and Bernhart, *Ber.*, 1908, **41**, 499 ; Pschorr and Zeidler, *Annalen*, 1910, **373**, 76 ; Rayman, *Bull.*, *soc. chim.*, 1876, ii, 26, 534, 43 ; Radziewanowski and Schram, *Chem. Zentrl.*, 1898, I, 1019).

In this investigation no catalyst or halogen carrier has been used. The chlorination apparatus is kept in sunlight which favours the side-chain chlorination. A special, but a very simple apparatus, has been described for the vapour phase chlorination,

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<center>EXPERIMENTAL</center>

Chlorination Apparatus.—Chlorination was carried out in a specially designed pyrex glass apparatus as shown in the diagram. The flask A was joined to the arm B of the triangle with a ground glass joint. Chlorine from the chlorine cylinder was dried by passing through concentrated sulphuric acid and was admitted at E. The rate of passing of the chlorine could be easily regulated. An empty safety bottle was used as a precaution against back suction. There was inserted a U-tube in the narrow tube D for preventing the vapours from travelling up and disturbing the regular flow of the condensed liquid back to the flask A.
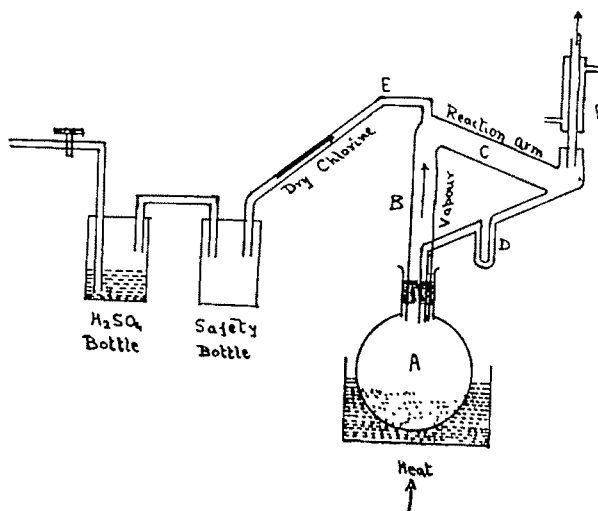
Chlorination of the substance.—The substance to be chlorinated was kept in the flask A which was heated in an oil-bath or metal-bath depending upon the boiling point of the substance to be chlorinated. The vapours of the substance came in contact and reacted with the dry chlorine vapours in the side arm C. This portion was as far as possible kept exposed to direct sunlight.

The chlorinated substance was condensed back by the double surface condenser F back to the flask A through a narrow tube D as shown. The end-point in the process of chlorination was known (*i*) when no vapours were generated, the chlorinated substance possessing invariably a much higher boiling point than that of the original substance, and (*ii*) by knowing the increase in weight of the substance due to chlorination.

Isolation and Identification of the Products.—The product after getting rid of excess of chlorine by repeatedly shaking with water, dilute alkali and again with water, was fractionally distilled under reduced pressure, the various fractions collected and identified in all cases by their boiling points and in most cases also by a study of the products of hydrolysis.

A typical experiment on Chlorination and Identification of the Products.—The *o*-cresol methyl ether (75 g.), b.p. 177°, prepared according to the method of Pinette, (*Ber.*, 1903, **36**, 1804 ; *Annalen*, 1888, **243**, 32, 37), was taken in the flask of the chlorination apparatus. The temperature of the oil-bath was kept at 180°. Chlorine was passed, and the vapour

TABLE I

Chlorination of cresol ethers

No.	Compound.	B.p.	Quantity taken for chlorination.	Temp. of the bath.	Time taken.	Products after chlorination.	References.
1.	o-Cresol methyl ether	171°	100 g.	190-95°	2½ hrs.	60-65% yield of 2-methoxybenzyl chloride, b.p. 111-112°/11 mm. Chlorination mostly in the side-chain	Pschorr, *Ber.*, 1900, 33, 165. Chlorination in the liquid phase gives b.p. 111-112°/11 mm.
2.	m-Cresol methyl ether	177°	100	Do	2½	25% of m-methoxybenzyl chloride, b.p. 124°/13 mm. 40% nuclear substituted products, b.p. 95-100°/13 mm. (b.p. 185°)	Pschorr (*Annalen*, 1912, 391, 44). PCl₃ on 3-methoxybenzyl alcohol gives the chloride, b.p. 124°/13 mm.
3	p-Cresol methyl ether	175°	100	190-200°	2½	25% of 4-methoxybenzyl chloride, b.p. 115-116°/15 mm. 40% nuclear substituted products, b.p. 100-105°/15 mm. 20% unconverted; 5% tar	Königs, Bernhart. (*Ber.*, 1908, 41, 499). Chlorination in the liquid phase; 4-methoxybenzyl chloride, b.p. 115°-116°/15 mm.
4.	o-Cresol ethyl ether	190°	90	220-30°	4	Chief product : 75% of o-ethoxybenzyl chloride, b.p. 216-220°; b.p. 125°/15 mm.	Chlorinating the corresponding alcohol (Pschorr and Zeidler, *Annalen*, 1910 373, 76) ; b. p. 125°/15 mm.
5.	m-Cresol ethyl ether	192°	80	220-40°	4	About 30% of m-ethoxybenzyl chloride b.p. 250°, and mostly in the nucleus	
6.	p-Cresol ethyl ether	189°	120	Do	4½	Chlorination gives many complex substituted products. One fraction below 210° and the other above 200°	Products unidentified
7.	Anisole	155°	100	180°	2½	80% o-chloroanisole, 195°-96° some p-chloroanisole, b.p. 88°/18 mm.	Henry (*Ber.*, 1869, 2, 710) Fischle (*Ber.*, 1878, 11, 1463) (Liquid phase chlorination)

TABLE II

Chlorination of other compounds

No.	Compound.	B.p.	Quantity taken for chlorina-tion.	Temp-of the bath.	Time taken in hr.	Products after chlorination.	References for the pre-paration of the same products in the liquid phase.
1.	Toluene	111°	200 g.	150-170°	4	80-85% conversion to benzyl chloride, b.p. 179°	Recovered toluene could again be used
2.	o-Xylene	140°	75	190-200°	3	50-55% conversion to o-xylene chloride, b.p. 197-200°	Chlorination in 2, 3 and 4 is accompanied by tar formation giving low yields, in the va-pour phase. Reaction proceeds almost entire ly in the side–chain and is facilitated by sunlight
3.	m-Xylene	138°	75	Do.	3	55-60% conversion to m-xylene chloride, b.p. 195-97° 10% xylyl dichloride, b.p. 250°	
4.	p-Xylene	136°	75	Do.	3	60% conversion to p-xylyl chloride, b.p. 200-202° and 10% dichloride, b.p. about 254°	These chloro compounds fume very strongly in air. These side chain chlorinated pro-ducts compare well with those obtained by Rayman (*Bull. soc. chim.*, 1874 *ii*, 26, 534, 43)
5.	o-Nitro-toluene	220°	100	220-230°	9	No chlorination proba-bly due to the steric hindrance of the nitro group	Radziewanowski and Schram, *Chem. Zentrl.*, 1898, I, 1019
6.	m-Nitro-toluene	232°	80	230-240°	6	No chlorination in the vapour phase	The chlorination in the liquid phase (for 6 and 7) goes smoothly
7.	p-Nitro-toluene	237°	40	240-250°	6	No chlorination in the vapour phase	Hanssermann and Beck, *Ber.*, 1892, 25, 2445
8.	Cineol $C_{10}H_{18}O$	176°	80	190-200°	4	Chlorocineol, b.p. 230-35°	*Ber.*, 1884, 17, 1978. Carl Hell and Ritter obtained the same, b.p. about 230°

of the o-cresol methyl ether reacted with the chlorine (preferably in sunlight) in the arms of the triangle. Chlorine was passed till completion of the reaction as indicated by (i) and (ii) mentioned above.

The product, thus obtained, after being freed from free chlorine was fractionally distilled under reduced pressure. The fraction distilling between 110° and 115°/11 mm. was collected and again fractionally distilled. The fraction boiling at 111-112°/11 mm. was collected ; yield 62·4 g. (nearly 65%).

Hydrolysis.—The fraction boiling at 111-12°/11 mm. (5 g.) is o-methoxybenzyl chloride. This was heated with alcoholic potash solution (2 N) for about 20 hours, and the reaction product after being worked up in the usual manner furnished pure o-methoxybenzyl alcohol (4 g.), b. p. 250°. Pschorr (*Ber.*, 1900, 33, 165) gets the o-methoxybenzyl alcohol (b.p. 248°-50°). This confirms that the original fraction was o-methoxybenzyl chloride.

The chlorination of the *ortho-* and *para-* methyl cresyl ethers, as also of *ortho-*, *meta-* and p-ethers of cresols and of *ortho-*, *meta-* and para-xylenes was carried out exactly as above. The vapour phase chlorination of the nitrotoluenes was not successful. Cineol and anisole were chlorinated for the first time in the vapour phase.

The results of the chlorination of the different compounds carried out in the vapour phase are given in Table I, II and III.

TABLE III

Estimation of chlorine and hydrolysis

No.	Compound.	% of chlorine Calc.	Found.	Hydrolysis product	References for the preparation of the same products.
1.	o-Methoxybenzyl chloride	22.66	23.00	o-Methoxybenzyl alcohol, b.p. 254-55°	Pschorr et al (Ber., 1900, 33, 165) obtained the alcohol b.p. 250°
2.	m-Methoxybenzyl chloride	Do.	22.8	m-Methoxybenzyl alcohol, b.p. 250°	cf. Mettler, Ber., 1906, 39, 2939 ; b.p. of m-methoxy alcohol 250°
3.	p-Methoxybenzyl chloride	Do.	22.63	Anisyl alcohol, b.p. 255-58°	Annalen, 1856, 98, 169, b.p. 255- 58°
4.	o-Ethoxybenzyl chloride	20.82	20.8	o-Ethoxybenzyl alcohol, b.p. 254°	Alcohol obtained by Botsch (Montash, 1880, 1, 621) b.p. 254
5.	m-Ethoxybenzyl chloride	Do.	21.02	..	..
6.	p-Ethoxybenzyl chloride	Do.	20.96	..	..
7.	o-, m- and p- Xylyl chlorides	25.2	25.05 25.21	..	Gundelach, Bull. soc. chim., 1876, 26, 43
			25.60		Reyman, Bull. Soc. chim., 1876, 26, 534

The boiling points have been corrected as to be under normal pressure.

DISCUSSION

The main products formed in this process of chlorination, *e.g.* with toluene, xylenes and the *ortho*-ethers of the cresols, are side-chain substitution products. The compounds containing chlorine in the ring are also formed, sometimes more than one, rendering the separation of these products rather difficult. But when the reaction is carried out in the sunlight and the operation properly controlled, chlorination proceeds mostly in the side-chain.

The following points require specific mention in connection with the experiments conducted in the vapour phase chlorinations :

(*i*)　If there is not an excess of the vapours of the substance to be chlorinated, there is a fire in the apparatus ; therefore, chlorine is regulated from time to time so that it is never in excess of the vapour of the substance.

(*ii*)　In these chlorinations there is always a tarry product formed due to the high temperature of the heating bath ; hence it is essential to avoid unnecessary high temperatures as far as possible. Because of the tar formation at the high temperature, yields are very low in some cases.

The chlorination of toluene yields very good results (about 85% conversion) yielding benzyl chloride. This is a better way of chlorinating toluene than the usual laboratory method of chlorinating in the liquid phase.

Throughout these chlorinations no halogen carrier or catalyst was used. Sunlight was found to be extremely useful for the side-chain chlorinations, improving the yields in the case of *ortho-*, *meta-* and *para*-methoxy and ethoxy-benzyl chlorides.

The chlorination of the nitrotoluenes was expected to proceed in the side-chain specially in the case of the *meta* and *para* compounds The *ortho* compound may not be chlorinated because of the steric hindrance of the nitro group in the compound. The side-chain chlorination of the *meta* and *para* compounds has, however, been carried out in the liquid phase (Hanssermann and Bock, *Ber.*, 1892, 25, 2445). The results are negative in the vapour phase even after prolonged chlorination.

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ACTION OF p-TOLUENE-SULPHONYL CHLORIDE ON NITROPHENOLS

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The action of p-toluene-sulphonyl chloride on ethyl 2-oxy-3 : 5-dinitro-1-benzoate and ethyl 4-oxy-3 : 5-dinitro-1-benzoate has been examined. In both the cases the OH group is replaced by chlorine, n the presence of diethylaniline as the condensing reagent.

These chloro compounds have been found to be identical with the dinitrochlorobenzoic esters obtained by nitrating o-and p-chlorobenzoic acids respectively and subsequent esterification.

The action of various amines and amino compounds on these chloro compounds has also been studied.

It has been observed by Ullmann and his collaborators (Ullmann and Nadai, *Ber.*, 1908, **41**, 1870, ; Ullmann and Bruick, *Ber*, 1908, **48**, 3939 3932 ; Ullmann and Sane, *Ber.*, 1911, **44**, 37 ; Sane and Joshi, *J. Chem. Soc.*, 1924, 2481 ; *J. Indian Chem. Soc.*, 1928, **5**, 299 ; Sane, Chakravarty and Pramanick, *ibid.*, 1932, **9**, 55 ; Sane and Joshi, *ibid.*, 1932,

9, 59 ; 1933, **10,** 459 ; Joshi, *ibid.,* 1933, **10,** 313) that *p*-toluene-sulphonyl chloride reacts with nitrophenols in two ways, mononitrophenols form *p*-toluene-sulphon esters either in the presence of sodium carbonate or diethylaniline as the condensing reagent ; poly-nitrophenols, specially containing NO_2 groups in the 2: 4 or 2:6 position to the OH group, also yield such esters in the presence of sodium carbonate as the condensing agent, but in the presence of diethylaniline they are mainly converted into poly-nitrochloroben- zenes, the OH group being replaced by Cl.

The chloro compounds obtained from these poly-nitrophenols are usually extremely reactive. In alcoholic, benzene or toluene solution, they react with a number of amines, yielding as a rule substituted nitroamines.

$$(NO_2)_2.C_6H_3.Cl + X.NH_2 \longrightarrow (NO_2)_2.C_6H_3.NHX + HCl$$
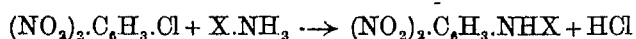
In the present paper, the above reaction has been extended to ethyl 2-oxy-3 : 5- dinitro-1-benzoate and ethyl 4-oxy-3 : 5-dinitro-1-benzoate and in both the cases chloro compounds have been obtained. The chloro compounds so obtained are found to be extremely reactive, as the presence of two nitro groups, specially in the *ortho* and *para* position of the halogen atom, makes it extremely labile. They have been reacted with a number of amines and the compounds so formed are isolated and characterised.

<center>E X P E R I M E N T A L</center>

Ethyl 3 : 5-*dinitro-2-oxy-1-benzoate* has been obtained either by nitrating salicylic acid and then esterifying (Cahour, *Annalen,* 1849, **69,** 235) or by the direct nitration of ethyl salicylate (*Annalen,* 1850, **74,** 313). The exact details of the second method are, however, not available in the literature. It has therefore been prepared by us in the following manner.

A solution of ethyl salicylate (25 c.c.) in glacial acetic acid (25 c.c.) was added during the course of 1 hour through a tap funnel to a mixture of fuming nitric acid (70 c.c.) and concentrated sulphuric acid (30 c.c.), which was cooled by a current of water. It was then allowed to stand for 24 hours and then heated finally over a wire-gauze for 5 minutes. After cooling, this mixture was poured into about 600 c.c. of water when the nitro com- pound separated out as a white crystalline powder. This was filtered and washed thoroughly with water, yield of the crude product (m.p. 96°) is about 37 g. On re- crystallising from alcohol the m.p. rose to 98°.

Ethyl 3 : 5-*Dinitro-2-chloro-1-benzaote.*—Ethyl 3 : 5-dinitrosalicylate (5 g.), *p*-toluene- sulphonyl chloride (4 g.) and diethylaniline (10 c.c.) were heated together in a flask over a water-bath for 4 hours. The mixture was then cooled and an excess of hydrochloric acid added to it. The semi-solid mass, which now separated out, was washed with water and then with a dilute solution of sodium carbonate and then again with water. The substance, which now solidified, was filtered and then recrystallised from alcohol, m.p. 54°.

This substance was found to be identical with the chlorobenzoic ester, which was obtained by the nitration of *o*-chlorobenzoic acid and subsequent esterification (Cohn,

Monatsh, 1901, 22, 388) and the correspondnig amino compounds obtained from these two, substances separately by the action of various amines were also found to be identical.

Ethyl 3 : 5-*dinitro-4-oxy-1-benzoate* was obtained by the esterfication of 3 : 5-dinitro-4-oxybenzoic acid according to the method of Salkowski (*Annalen*, 1872, 163, 44).

Ethyl 3 : 5-*Dinitro-4-chloro-1-benzoate.*—Ethyl 3 : 5-dinitro-4-oxy-1-benzoate (2.5 g.), *p*-toluene-sulphonyl-chloride (2 g.) and diethylaniline (5 c.c.) were heated together in a flask over a water-bath for 4 hours. It was then cooled and digested with hydrochloric acid. The chloro compound was then isolated in the usual way and finally recrystallised from alcohol, m.p. 82°.

This substance was also found to be identical with the chlorodinitrobenzoic ester, which was obtained by the nitration of *para*-chlorobenzoic acid and esterification (Ullmann *Annalen*, 1908, 366, 93), and the corresponding amino compounds obtained from these substances separately by the action of various amines were also found to be identical.

Reaction with Amines.—The calculated quantities of the chloro compound and the the appropriate amine (slight excess) were dissolved separately in alcohol and then mixed and refluxed for 1 hour. The alcohol was then distilled off and the excess of amine removed by the addition of concentrated hydrochloric acid. The solid which now separated out was washed with boiling water and then recrystallised from a suitable solvent.

The various amino compounds obtained by the action of a number of amines on these two chlorodinitrobenzoic esters have been given in Table I

TABLE I

Reactants.		Formulae.	M.p.	Colour.	Nitrogen	
					Found.	Calc.
Ethyl 3 : 5-di-nitro-2-chloro 1-benzoate	Aniline	$X.NH.C_6H_5$	140°	Yellow	12.30%	12.70%
,,	*o*-Toluidine	$X.NH.C_6H_4 CH_3$	119°	Yellow	11.80	12.17
,,	*m*-Toluidine	$X.NH.C_6H_4.CH_3$	132°	Yellow	11.60	12.17
,,	Piperidine	$X.N.C_5H_{10}$	109°	Lemon-yellow	12.75	13.00
,,	*o*-Amino-phenol	$X.NH.C_6H_4.OH$	150°	Chocolate-brown	11.70	12.09
,,	*o*-Anisidine	$X.NH.C_6H_4.OCH_3$	163°	Scarlet-red	11.30	11.66
Ethyl 3 : 5 di-nitro 4-chloro-1-benzoate	Aniline	$Y.NH.C_6H_5$	153°	Orange-yellow	12.50	12.76
,,	*o*-Toluidine	$Y.NH.C_6H_4.CH_3$	151°	Turmeric yellow	11.90	12.17
,,	*m*-Toluidine	$Y.NH.C_6H_4.CH_3$	141°	Orange	12.10	12.17
,,	Piperidine	$Y.N.C_5H_{10}$	90°	Yellow	12.70	13.00
,,	*o*-Amino-phenol	$Y.NH.C_6H_4OH$	168°	Orange	12.40	12.09
,,	*o*-Anisidine	$Y.NH.C_6H_4.OCH_3$	163°	Red	11.65	11.66

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where   X = NO$_2$ $\langle$ CO$_2$Et / NO$_2$ $\rangle$—   Y = CO$_2$Et $\langle$ NO$_2$ / NO$_3$ $\rangle$—
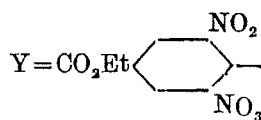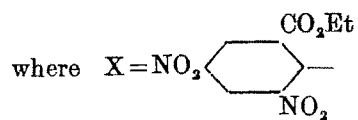
The author thanks Dr. S. M. Sane for the help and guidance during the course of the work and the Lucknow University for the facilities offered for research.
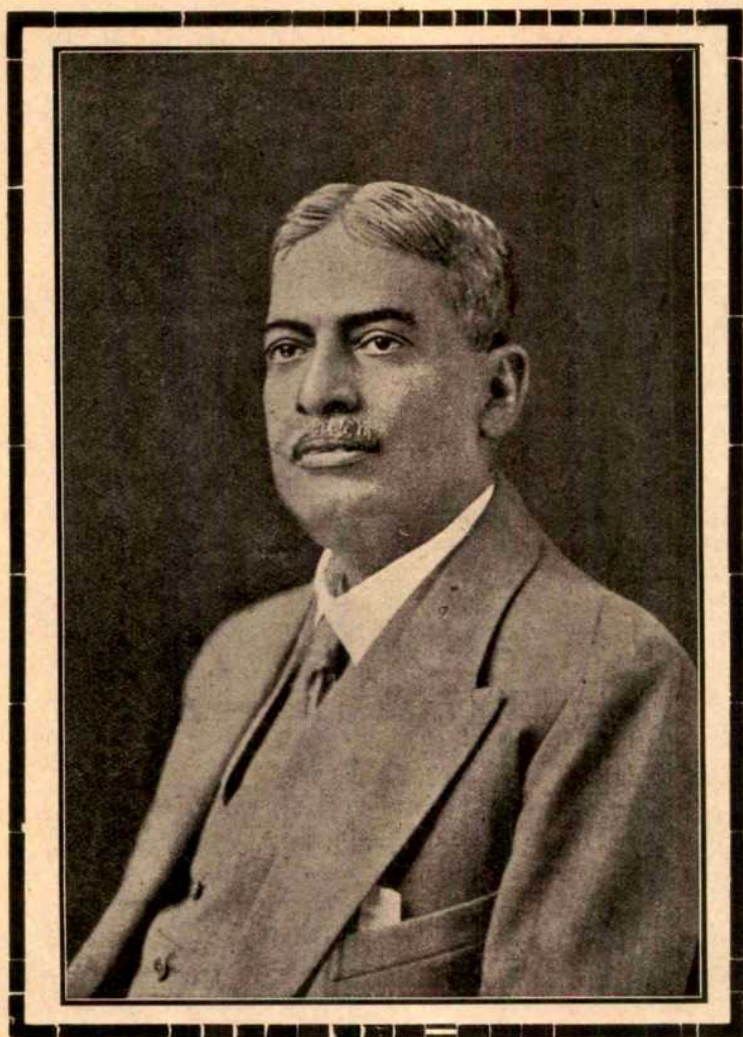
The Late Sir U. N. BRAHMACHARI, Kt., M.A., M.D., Ph.D.,
F.N.I., F.R.A.S.B., F.S.M.F. (Bengal).

OBITUARY

SIR UPENDRANATH BRAHMACHARI, KT., M.A., M.D., PH.D., F.R.A.S.B., F.N.I.

Born : 19th *Dec.*, 1873.   *Died* : 6th *Feb.*, 1946

The death of Sir Upendranath Brahmachari on the 6th February, 1946, at the age of 73, removes a remarkable personality from the world of science and medicine. In him India has lost a very able son, who had been largely instrumental in propagating India's scientific activity beyond the frontiers of the country. Dr. Brahmachari was simultaneously a medical man and a chemist so that he can be described as the ' father of chemotherapeutic researches ' in India.

Upendranath was the son of late Dr. Nilmoni Brahmachari, a medical practioner of Jamalpore (Dist. Monghyr). As a student, Brahmachari showed promise from the very beginning and when he took his B.A. Degree from the Hooghly College in 1893 standing first in Honours in Mathematics and receiving the Thwyatas medal, everybody interested in him felt that young Brahmachari was on the threshold of a promising career. From Hooghly College, Brahmachari came to the Presidency College, Calcutta, to study Chemistry and within a year, largely influenced by his father, he joined the Calcutta Medical College. In 1894, while still a student of the first year class in the Medical College, Brahmachari took his Master's Degree in Chemistry in the First Class, securing the silver medal in Chemistry of the University. He passed the M.B. Examination in 1898 standing first in Medicine and Surgery, proving thereby a capacity for scientific work which few students of his generation possessed. He was clearly the most intelligent and progressive student of his time and became early known for his deep knowledge, penetrating clinical acumen and scholarly habits.

Immediately after graduation from the Calcutta Medical College, Brahmachari was chosen by his Professors and offered a post in the Bengal-Medical Service. In this capacity he went to the Dacca Medical School as Teacher of Pathology and Materia Medica. Here he built up within a comparatively short time a very good practice and also engaged himself in researches with Sir Neil Campbell, Superintendent of the Medical School. In-spite of his growing popularity and the ever-increasing demands made on his time by patients, he managed to keep his academic activities alive. In 1902, he obtained his M.D. Degree and within the next two years secured the Ph.D. Degree in Physiology by submitting a thesis on ' Studies in Haemolysis.' He thus became the first medical man to combine a double Doctorate.

In 1905, Dr. Brahmachari was transferred to the Campbell Medical School, Calcutta, as Teacher of Medicine and remained in this Institution until 1923. From 1923-27 he became the Additional Physician to the Calcutta Medical College Hospitals—the first non-I.M.S. physician to be so honoured—and after retirement, he took up the Honorary posts of Professor of Tropical Medicine at the Carmichael Medical College and Professor of Bio-chemistry at the Calcutta University, which duties he continued to perform until death snatched him away.

Early during his active medical career, Brahmachari got interested in the treatment of ' fevers,' because during those days Bengal was ravaged with a wide occurrence of malaria, Black-water fever and an epidemic fever (commonly known then as ' Burdwan fever '), which was afterwards recognised as Kala-azar through the discovery of the Leishman—Donovan parasites in 1903. When the diagnosis of Kala-azar was scientifically established, its treatment began to engage the attention of workers in various parts of the world. Manson was the first to introduce antimonial preparations in the treatment of Kala-azar, although the therapeutic virtues of antimony in certain diseases already became known as far back as the 15th century. In 1913, Vianna in Brazil reported the cure of South American forms of skin and mucous membrane Leishmaniasis with intravenous administration of tartar emetic. DiCristina and Caronia were the first to record the successful use of tartar emetic intravenously in Mediterranean Kala-azar in Sicily in 1915. About the same year, Rogers claimed to have obtained favourable results in a number of cases in India with tartar emetic, independently of DiCristina and Caronia. Brahmachari, who was following the trend of work from the very early stages and who had already experimented with a number of antimony preparations in the treatment of Kala-azar, started the use of sodium antimonial tartrate towards the end of 1915. It was found to be less toxic than tartar emetic and had replaced the latter salt in the hands of many workers in India. This treatment, however, had the disadvantage of being long and tedious without very successful results. Hence many patients left off treatment before complete cure.

With a grant from the Indian Research Fund Association, Brahmachari got together a band of young organic chemists, mostly students of the Calcutta University, and started systematic work on the chemotherapy of Kala-azar with antimony compounds. From his clinical observations in the wards of the Campbel Hospital, which incidentally offered a wide range of Kala-azar cases, he was convinced as to the curative value of antimony in this infection, but felt that the dosage of antimony administered was not enough. Unless the toxicity of the antimony salt could be reduced, an increase in effective dosage would not be possible. He, therefore, tried ' metallic antimony ' in a state of fine subdivision and also ' colloidal metallic antimony ' but still the position remained unsatisfactory. From an analogy of the value of the corresponding arsenic compounds (' Arsacetin ' and ' Atoxyl ') in the treatment of certain protozoal diseases and from the more or less successful use of acetyl compound of antimony (Stibacetin, Stibenyl) in the treatment of Kala-azar and other forms of leishmaniasis, Brahmachari concentrated his attention on *para*-aminophenylstibinic acid and similar aromatic antimonials. It is not exactly known how Brahmachari conceived the idea of combining stibenylic acid with urea, but it is possible that he might have been trying to get painless antimonial compounds suitable for intramuscular administration, and was guided by the fact that combination with urea of an irritant aromatic antimonial would reduce the pain and discomfort in the same way as is obtainable with quinine and urea injections.

In 1920, the compound known as ' Urea-stibamine ' was produced, which even during early trials showed clear promise as a very potent remedy in the treatment of

Kala-azar. The chemical composition of Urea-stibamine is still undecided. It was originally reported to be a substance composed of urea and *para*-aminophenylstibinic acid with the empirical formula, $C_7H_{12}O_4N_2Sb$.[1] Later on, it was suggested that the compound was identical with ammonium *para*-carbamidophenylstibinate, $NH_2CO.NH.C_6H_5SbO(OH).ONH_4$.[2] Ghosh *et al*[3] and Gray *et al*[4] gave definite evidence that urea-stibamine was not a single substance of definite composition and the latter group of workers showed that the 'effective active principle 'was a di-substituted urea, *S*-diphenylcarbamide-4 : 4:distibinic acid. The antomony content of 'various commercial samples was shown by Ghosh *et al* to vary between 20 and 43%, while Gray *et al* reported a comparatively small range of variation in antimony content from 44.19 to 48.6%. Brahmachari[5] appeared to have accepted the results of Gray *et al* in this regard, and emphasised that the divergent results obtained by different investigators were due to different brands of ' so-called urea-stibamine,' not conforming to his original specifications, being put on the Indian market.

Whatever be its chemical entity, most of the samples of Urea-stibamine appear to have an antimony content varying from 38 to 42% and an intravenous toxicity in white mice varying from 200 to 250 milligrams per kg.[6] Laboratory and clinical trials all over Assam and other endemic areas indicated, in no uncertain terms, the remarkable efficacy of the drug. It is estimated that with the discovery and subsequent extended use of Urea-stibamine in certain areas in Assam, the mortality rate from the disease (including complicated cases) was reduced from 99% to 1 to 2%. That Urea-stiabamine is a real specific in the treatment of Kala-azar has been proved beyond doubt by workers in India, China, Egypt and elsewhere.

Brahmachari's name, as the discoverer of Urea-stibamine, has gone far and wide and he is certainly one of the few medical men whose contributions can be mentioned side by side with other discoverers of international fame. However, Brahmachari's contributions to medicine are not limited only to the discovery of Urea-stibamine. As a diagnostician, he became known for his discovery of a skin manifestation of leishmaniasis known as ' Dermal leishmanoid.' This condition was previously confused with Leprosy. He also made significant contributions to chemotherapy in general through his studies of the quinoline and acridine compounds. He had been a prolific writer and had regularly contributed articles on various phases of synthesis of the quinoline compounds in the *Journal of the Indian Chemical Society.*

Dr. Brahmachari was the author of several books and also contributed liberally to the scientific journals of his time, both in India and abroad. His first book on "Kala-azar —its treatment" was published in 1917. An enlarged edition of this was later published in England in 1926. In 'Carl Mense's Handbuch der Tropenkrankheiten, Vol. IV, he contributed a masterly chapter on Kala-azar in 1926. Under the title of ' Campaign against Kala-azar in India,' he gave a number of informative accounts in the Jubilee publication on the 80th birthday of Prof. Dr. Bernhard Nocht of Hamburgh. His article on ' Infantile Biliary cirrhosis in India ' in the British Encyclopædia of Medical Practice is at once an informative and readable article. His ' Gleanings from my researches '

in two volumes appeared in 1940.   There is hardly any world literature in tropical medicine where Sir Upendranath's contributions are not eulogistically referred to. .

As is to be expected for a man of Dr. Brahmachari's achievements and ability, he received almost all types of honours and distinction which India could confer on him.   He was made the President of the Indian Science Congress, the President of the Indian Chemical Society and was a Fellow and Patron of the Society for well over 20 years.   He was a foundation Fellow of the National Institute of Sciences of India and was actively associated with the academic and cultural activities of the Calcutta University. His discovery of Urea-stibamine brought him fortune which seldom comes to the lot of a medical man.   This, however, never moved him away from a life of dynamic activity and research to a life of sedate repose and re-laxation.   Brahmachari remained the same magnetic, alert and always attentive individual, as he was in his earlier days at the beginning of a life of most fruitful career.   From his *alma mater*, the Calcutta University, he received prizes, medals and honours almost unique in its history.   From the Royal Asiatic Society of Bengal, from the the School of Tropical Medicine and from many other scientific and research organisations, he received recognition through the awards of medals and prizes.   He was made a Rai Bahadur, was awarded the *Kaiser-i-Hind* Gold Medal and was later knighted.

As a man, Sir Upendranath had a very affectionate heart, though with a somewhat rough exterior.   He was a difficult man to impress but when once impressed, would always do the right thing and push up the right candidates.   Towards the later part of his life, he earned the reputation of being a philanthropist and made free gifts of Urea-stibamine to a large number of relief organisations and other charities towards scientific and industrial research.   The life-work of Brahmachari as one of the pioneers of chemotherapeutic research in India and probably also in the East will long continue to serve as a great inspiration to all those who are privileged to carry on the work in his field of choice.   He was out and out a product of an Indian University and showed effectively, for the first time, that given the minimum of opportunities, an Indian can rise to any height and can make contributions which may raise India to a world level.   India and Indian scientists would long mourn the loss of Brahmachari, because the void that he has created would take a long time to be filled.

B. Mukerji.

[1]   Brahmachari, *Ind. J. Med. Res.*, 10, 492 (1922)
[2]   Niyogy, *J. Indian Chem. Soc.*, 6, 753 (1928)
[3]   Ghosh *et al.*, *Ind. J. Med. Res.*, 16, 461 (1928)
[4]   Gray *et al.*, *Proc. Roy Soc. B.*, 108, 54 (1931)
[5]   Brahmachari, *Nature*, 146, 1021 (1940) ; 146, 546 (1940)
[6]   Guha, Dutta & Muherji, *Nature*, 151, Jan. 23, (1941)
[7]   Bose & Mukerji, *Ind. J. Med. Res.*, 33, 151 (1945)
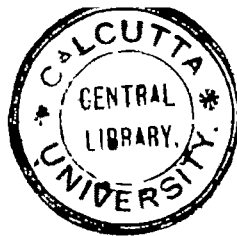
HYDRIDES OF COBALT

By R. C. Ray and R. B. N. Sahai

Hydrides of cobalt (mono and di) have been prepared according to the method described previously (*J. Indian Chem. Soc.*, 1943, 20, 213), and their properties studied. Dissociation pressures of the hydrides at different temperatures have been measured and their heats of formation calculated from the dissociation pressures. The apparatus previously described has been improved upon and data on dissociation pressures of nickel hydrides redetermined.

In a previous paper (*J. Indian Chem. Soc.*, 1943, 20, 213) the preparation and properties of the hydrides of nickel have been described. Following exactly the same procedure the hydrides of cobalt have been prepared. The reaction takes place according to the equation,

$$CoCl_2 + 2PhMgBr + 2H_2 = CoH_2 + 2C_6H_6 + MgBr_2 + MgCl_2$$

The apparatus used for preparation of this hydride in large quantities was almost the same as that used for nickel hydride (*loc. cit.*). Perfectly anhydrous and finely powdered cobalt chloride was added to dry ether in a wide-mouthed flask provided with a rubber bung through which passed a mercury-sealed glass stirrer, a dropping funnel and inlet and outlet tubes for hydrogen. A stream of hydrogen from the Kipp's apparatus, purified by passing through a mixture of potassium dichromate and conc. sulphuric acid, over red hot copper and finally through conc. sulphuric acid, was passed through the flask. When all the air had been displaced, a solution of freshly prepared PhMgBr in dry ether was run in. The phenyl magnesium bromide was freshly prepared otherwise the reaction did not take place satisfactorily. For every gram of cobalt chloride, 100 c.c. of dry ether were put into the flask and 50 c.c. of ethereal solution of PhMgBr containing 0·1 mol. of magnesium were used for the reaction. As soon as PhMgBr was introduced the colour of the suspension began to change and finally it became dark grey. The reaction took about 9 hours to complete.

Contrary to Balandin, Erofeev, Pecherskaya and Stakhanova's (*J. Gen. Chem. U. S. S. R.*, 1941, 11, 577 ; *Acta Physicochim. U.S.S.R.*, 1943, 18, 157 ; 1943, 18, 300) assumption that the metal is first precipitated in the colloidal form which absorbs hydrogen producing different hydrides, it was found that only one hydride is formed, although the preparations were carried out at 0°, 15° and 25° and in some cases the hydrogen was passed for longer periods even after the completion of the reaction. When the experiment was over, the composition of the substance was determined in the following manner. As the hydride was quantitatively decomposed by water or alcohol, a small quantity of the substance was taken out, introduced into a small flask, fitted with a dropping funnel and a delivery tube, which was connected to a Hempel's burette. A measured volume of dilute alcohol was added and the gas evolved was collected and measured. The volume of the hydrogen evolved by the hydride was obtained by subtracting the volume of the liquid introduced from

the total volume of the gas collected. The cobalt precipitated was dissolved in dilute· sulphuric acid and precipitated by ⍺-nitroso-β-naphthol. The precipitate was ignited and the cobalt estimated as $CoSO_4$ and also by dissolving the ignited residue in acid and estimating cobalt electrolytically. A large number of preparations was made at each temperature and the product obtained in each case was analysed and the results agreed quite closely. One typical series of results is recorded below.

TABLE   I

Temp. of prepn.	Time of passing H_2.	Wt. of Co.	Vol. of H_2 (N. T. P.)	Ratio Co/H.	Composition.
0°	8 hrs.	0.3885 g.	154.0 c.c.	1:2.09	CoH_2
0°	12	0.2738	100.5	1:1.96	,,
15°	9	0.3730	147.8	1:2.11	,,
15°	15	0.2339	91.5	1:2.05	,,
25°	10	0.3067	120.0	1:2.08	·,,
25°	20	0.3835	150.0	1:2.07	,,

The dissociation pressures of the hydride were determined at different temperatures. The hydride was repeatedly washed with ether to remove the organic matter and the magnesium salts present. It was then dried by putting it in a test tube at 25° and passing a stream of dry hydrogen through it. The substance thus obtained was perfectly dry and fairly pure though it still contained traces of magnesium salts as impurities.

For the purpose of measurement of dissociation pressure an all-glass apparatus as shown in Fig. 1 was used. It consisted of a long, closed-limb mercury manometer M connected with a bulb B which contained the substance and a tap T through which the apparatus was evacuated by means of a Töpler pump. The apparatus was then put inside an electrically maintained air thermostat which could be kept constant to $\pm 0.2°$. The thermostat was set at definite temperatures and at each temperature it was kept for sufficiently long time until equilibrium was attained. At each temperature the heights of mercury in the two arms of the manometer were read off by means of a cathetometer provided with a vertical scale and a vernier. After the equilibrium had been established· at a particular temperature and the readings had been taken, the apparatus was connected to the pump again and slightly evacuated to disturb the equilibrium. On keeping the apparatus at that temperature the original pressure was regained. This operation was carried out at every point
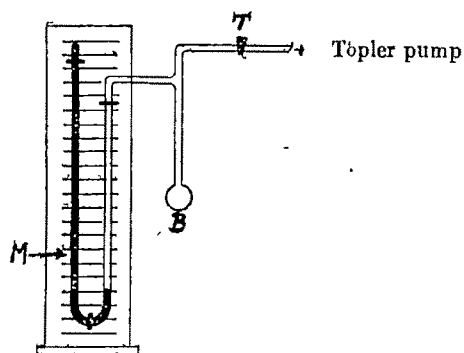
FIG. 1

Töpler pump

of observation. It was observed that up to 44° the pressure recorded in the first instance was reproducible even when the equilibrium was disturbed showing that the hydride is stable up to that temperature. At 45·8°, however, on disturbing the equilibrium after the first observation the pressure did not come back to the original value, but gave a lower value showing definitely that a new phase had appeared having a lower dissociation pressure than the first one. The region between 44° and 45·8°, indicated by the dotted line in Fig. 2, could not be explored with greater precision owing to experimental difficulties. Hence it can only be said that the transition lies somewhere between 44° and 45·8°. The temperature of the thermostat was further raised gradually up to 100° and the readings of pressure taken at different temperatures. The values were found to be reproducible and no other break was noticed. The composition of second solid phase at various temperatures above 50° was determined by analysis. It always corresponded to the formula CoH. One typical result for each temperature is tabulated below.

TABLE   II

Temp. of bath.	Wt. of Co.	Vol. of H_2 (N. T. P.)	Ratio Co/H	Composition.
50°	0.1744 g.	30.5 c.c.	1:0.94	CoH
90	0.2300	41.1	1:0.95	,,
130	0.2020	40.7	1:1.05	,,
150	0.2737	50.2	1:0.98	,,

It is evident from the table above that CoH is stable up to 150°. The dissociation pressure of the monohydride was measured from room temperature to 90° in the manner described for the dihydride. Several sets of measurements were carried out. The graphs plotted were almost identical. The mean values of the dissociation pressure at particular temperatures are recorded below.

TABLE   III   TABLE   IV

Compound : CoH_2 Compound : CoH

Temp.	Press.	$1/T$ (abs.)	$\log_{10} p$	Temp.	Press.	$1/T$ (abs.)	$\log_{10} p$
				29.8°	1.85 cm.	0.003302	0.2672
30.0°	4.02 cm.	0.003300	0.6042	35.0	2.95	0.003247	0.4698
32.5	4.70	0.003274	0.6721	40.8	4.80	0.003192	0.6885
35.0	5.30	0.003247	0.7243	45.8	6.55	0.003187	0.8162
37.9	6.00	0.003217	0.7782	50.2	8.35	0.003094	0.9217
40.8	6.90	0.003187	0.8388	55.4	10.50	0.003045	1.0212
44.0	7.80	0.003155	0.8921	66.4	14.50	0.002946	1.1614
				79.9	19.67	——	——
				90.0	23.50	——	——

The results are represented graphically in Fig. 2 in which the upper curve is for CoH_2 which decomposes completely into CoH at a temperature somewhere between 44° and 45.8°. The unexplored region is indicated by the dotted line. The lower curve is for CoH. The transition from CoH_2 to CoH takes place in the region indicated by the dotted line.

The reactions $2CoH_2 \rightleftharpoons 2CoH + H_2$ and $2CoH \rightleftharpoons 2Co + H_2$ are reversible reactions but the dissociation of CoH_2 to CoH and H, with increasing temperature takes only a few hours to reach the equilibrium for a particular temperature. The rate of recombination of CoH and H to CoH_2, however, is extremely slow. Similar is the case for the second reaction.
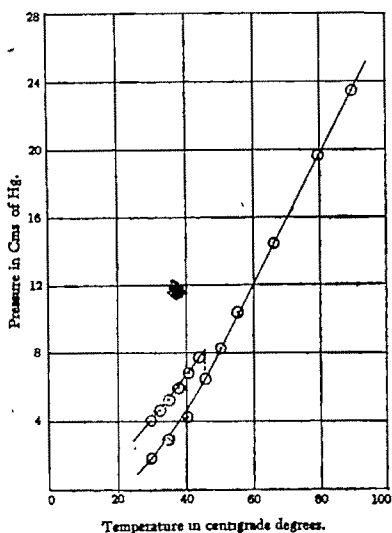
FIG 2.   FIG. 3.
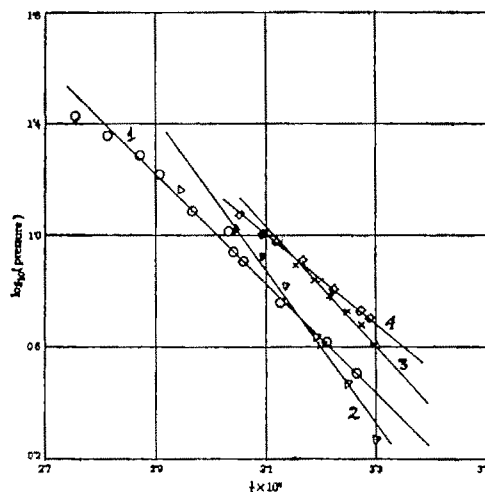
Curves 1—4 refer respectively to
NiH, CoH, CoH_2 and NiH_2.

The density of the dihydride was determined with respect to ether and was found to have a value of 0·533 at 30°.

The cobalt dihydride is a dark grey, almost black substance. It is fairly stable when kept under ether at temperatures below 5°. When purified and dried it has a crystalline appearance. It decomposes rapidly in contact with moist air but in dry air the rate of decomposition is slow at the ordinary temperature. It is decomposed quantitatively by water, alcohol or dilute acids, with the first two the decomposition is catalytic in nature resulting in the separation of metallic cobalt and only two atoms of hydrogen are evolved per molecule of the hydride, but with acids the cobalt salt of the acid is formed and four molecules of hydrogen are evolved per molecule of the hydride. The formation of the cobalt dihydride takes place in the same manner as suggested by Weichselfelder (loc. cit.) for the nickel hydride and in this case also traces of diphenyl etc. are produced as impurities. The properties of the monohydride are similar to dihydride. It is more stable than the dihydride. It has grey colour and crystalline appearance,

As discussed in the previous paper the heat of formation of CoH_2 and CoH was calculated by means of the Clapeyron-Clausius equation :

$$\frac{dlnp}{dT} = \frac{Q}{RT^2}$$

which on integration gives :

$$Q = R. \frac{ln\frac{p_2}{p_1}}{\left(\frac{1}{T_2} - \frac{1}{T_1}\right)}$$

FIG. 4.
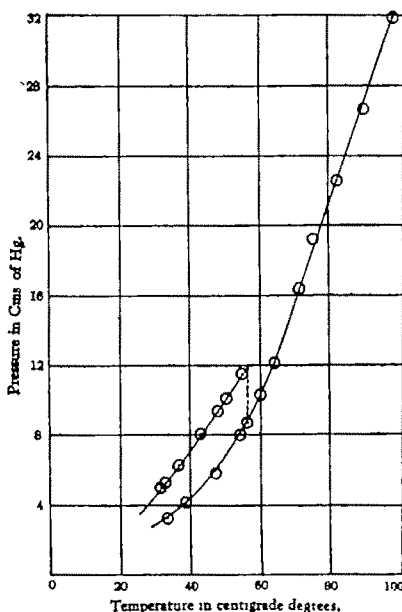
In Fig. 3 $log_{10}p$ is plotted against $(1/T)10^3$ from which the values of the heat of formation of the two hydrides were calculated with reference to several points on the two straight lines and the mean values of the heat of formation over a range of temperature between 30° and 44° in the case of CoH_2 and from the room temperature to 90° in the case of CoH is given below :

$$CoH_2 = 9,400 \ cal$$
$$CoH = 12,580 \ cal.$$

The values of the heats of formation indicate that the monohydride is much more stable than the dihydride. This implies that the monohydride does not constitute a primary or an intermediate stage in the formation of the dihydride, and thus furnishes an indirect evidence that hydrogen does not react with the colloidal metal as suggested by the Russian workers.

After the paper on the nickel hydrides (*loc. cit.*) had been published it was found that the dissociation pressure data, obtained for the nickel hydrides by the apparatus given therein, was subject to many corrections and some errors had inadvertently crept up in the calorimeter hence the dissociation pressures of the nickel hydrides were again measured by the help of the new apparatus described

above and the mean of several sets of data obtained are given below in Tables V and VI. The observations were repeated many times and the graphs plotted in each case were found to be identical.

TABLE V			
Compound : NiH_2.			
Temp.	Press.	$1/T$ (abs.)	$\log_{10} p$.
31.0°	4.97 cm.	0.003289	0.6964
32.6	5.30	0.003273	0 7243
37.2	6.30	0.003224	0.7993
42.7	8.05	0.003168	0.9058
47.8	9.40	0.003118	0.9731
50.3	10.10	0.003093	1.0043
54.8	11.50	0.003050	1.0807

TABLE VI			
Compound : NiH			
Temp,	Press.	$1/T$ (abs.).	$\log_{10} p$.
33.2°	3.23 cm.	0.003266	0 5092
38.4	4.15	0.003211	0.6180
46.9	5.75	0.003126	0.7597
54.0	8.05	0.003058	0.9058
56.0	8.70	0.003040	0.9395
60.0	10.30	0.003030	1.0128
64 2	12.17	0.002965	1.0853
71.3	16 40	0.002904	1 2148
75.5	19.20	0.002870	1 2833
82.6	22.60	0.002812	1.3541
90.2	26.60	0.002753	1.4249
98.9	31.80	—	—

The results tabulated above are represented graphically in Fig. 4. The upper curve is for NiH_2 and the lower curve is for NiH. The transition takes place somewhere between 54·8° and 56° as indicated by the dotted line. The reactions noted below have also been found to be reversible but the rate of dissociation is much quicker compared to the rate of recombination.

$$2NiH_2 \leftrightarrows 2NiH + H_2$$
$$2NiH \rightleftarrows 2Ni + H_2$$
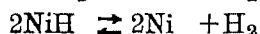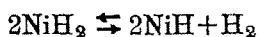
The density of the dihydride of nickel has been determined with respect to ether and has a value of 0 508 at 31°.

The heats of formation of the two nickel hydrides have been recalculated from the new data represented graphically in Fig. 3, in which $\log_{10} p$ is plotted against $(1/T)10^3$ and the mean value over a range of temperature from 33° to the transition temperature in the case of NiH_2 and upto about 100° in the case of NiH is given below :

$$NiH_2 \quad = \quad 7,312 \text{ calories.}$$
$$NiH \quad = \quad 8,835 \text{ calories.}$$

In conclusion we wish to record our thanks to Dr. P. B. Ganguly and Prof. P. C. Sinha for their kind interest and also to the Vice-Chancellor of the Patna University for granting research scholarship to one of us (R.B.N.S.).

HYDRIDES OF IRON

By R. C. Ray and R. B. N. Sahai

Hydrides of the bi-and tervalent iron have been prepared in a similar way as hydrides of nickel and cobalt. Properties of iron hydrides have been studied and dissociation products of the iron hydrides have been determined and heats of formation of the hydrides calculated from the dissociation pressure at different temperatures.

In two previous papers (*J. Indian Chem. Soc.*, 1943, **20**, 213; 1946, **23**, 61) the preparation and properties of the hydrides of nickel and cobalt have been described. Following exactly the same method of preparation, the hydrides of bi- and tervalent iron have been prepared. When finely powdered anhydrous ferrous chloride suspended in dry ether is treated with an ether solution of phenyl magnesium bromide in a stream of dry hydrogen, a dark grey precipitate of iron dihydride separates. The reaction is supposed to take place according to the equation,

$$FeCl_2 + 2PhMgBr + 2H_2 = FeH_2 + 2C_6H_6 + MgBr_2 + MgCl_2$$

Similarly when a solution of anhydrous $FeCl_3$ in dry ether interacts with PhMgBr solution in presence of dry hydrogen, a black precipitate of FeH_3 separates slowly. The reaction in this case is as follows :

$$2FeCl_3 + 6PhMgBr + 6H_2 = 2FeH_3 + 6C_6H_6 + 3MgBr_2 + 3MgCl_2.$$
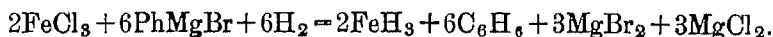
For every gram of ferrous chloride 100 c.c. of dry ether and 50 c.c. of ethereal solution of PhMgBr containing 0.1 mol. of magnesium were used for the reaction As soon as PhMgBr was introduced, the colour of the suspension began to change and finally it became dark grey. The reaction took about 13 to 14 hours to complete. The preparations were carried out at 0°, 15° and 25° by immersing the reaction flask in a suitable bath maintained at the required temperatures, and in some cases hydrogen was passed for a very long time after the reaction was complete. When experiment was over, a small quantity of the substance was removed and its composition determined in the following manner : A small quantity of the substance was introduced into a small flask fitted with a dropping funnel and a delivery tube which was connected to a Hempel's burette. A measured volume of dilute sulphuric acid was introduced into the flask through the dropping funnel and the evolved gas was collected. The hydride decomposed quantitatively, and the volume of hydrogen evolved was obtained by subtracting the volume of the liquid introduced from the total volume of the gas collected. The solution of the iron salt was evaporated to dryness and gently ignited to burn off the organic matter. The iron oxide thus formed was dissolved again in dilute sulphuric acid and the iron precipitated as hydroxide and weighed as oxide. From the weight of the oxide the weight of iron in the hydride was calculated. A large number of preparations was made at each temperature and the product obtained in each case was analysed and the results agreed quite closely. Some typical results for each temperature are recorded below.

TABLE I

Compound : FeH$_3$

Temp.	Time of passing H$_2$.	Wt. of Fe.	Volume of·H$_2$ (N. T. P.) obs.	Vol. of H$_2$ from hydride.	Ratio Fe/H.	Composition
0°	15 hrs.	0.0819g.	68.4 c.c.	34.2 c.c.	1 : 2.07	FeH$_2$
0	20	0.1084	91.5	45.7	1 : 2.05	,,
15	13	0.0950	79.2	39.6	1 : 2.06	,,
15	25	0.1204	94.4	47.2	1 : 1.93	,,
25	17	0 0785	61.4	30.7	1 : 1.97	,,
25	30	0.1625	130.8	65.4	1 : 2.03	,,

Trihydride of iron was likewise prepared from anhydrous ferric chloride As anhydrous ferric chloride is soluble in ether a definite volume of its solution containing a known weight of the salt was taken in the flask and the requisite amount of freshly prepared phenyl magnesium bromide solution was dropped in and pure and dry hydrogen was passed through the vessel. The reaction took about 5 hours to complete. After the completion of the reaction the hydride separated out as a black mass. The preparation of the trihydride was also carried out at various temperatures and hydrogen passed for varying lengths of time The composition of each product was determined in the manner described above. A large number of preparations was made at each temperature and the product obtained in each case was analysed and the composition of the hydride was found to be the same in each case. Some typical results for the product obtained at each temperature are recorded below.

TABLE II

Compound : FeH$_3$

Temp.	Time of passing H$_2$.	Wt. of Fe.	Volume of H$_2$ (N. T. P.) obs.	Vol. of H$_2$ from hydride.	Ratio Fe/H.	Composition.
0°	4 hrs.	0.0799 g.	79.5 c.c.	47.7 c.c.	1 : 3.00	FeH$_3$
0	10	0.0680	68.0	40.8	1 : 3.08	,,
15	5	0.1504	142.7	85.6	1 : 2.90	,,
15	15	0.1385	136.6	81.9	1 : 2.97	,,
25	8	0.1860	180.0	108.0	1 : 2.95	,,
25	20	0.1593	158.7	95.1	1 : 3.06	,,

It is interesting to note the difference between the action of water on the hydrides of nickel and cobalt and those of iron. In the case of cobalt and nickel hydrides, water liberates hydrogen and the metals are separated, which react with acids liberating an equal volume of hydrogen and are converted into the salts of the acids used. As regards the iron hydrides, the first part of the reaction—liberation of hydrogen and separation of the metal—is similar, but the finely-divided iron which separates reacts further with water forming hydroxides of the metal with evolution

of hydrogen, so that no further hydrogen is evolved on the addition of an acid. That metallic iron first separates out when the hydride is treated with water and then the finely-divided iron at once combines with the (OH) group of water to form the hydroxides $Fe(OH)_2$ and $Fe(OH)_3$ is shown by the fact that by the action of water on the two hydrides four atoms of hydrogen are liberated per molecule of the dihydride and five atoms of hydrogen per molecule of the trihydride. The reactions of water on the two hydrides may well be represented by the equations :

$$(1) \quad FeH_2 + [H_2O] - Fe + H_2 + [H_2O] \qquad (2) \; 2FeH_3 + [H_2O] = 2Fe + 3H_2 + [H_2O]$$
$$Fe + 2H_2O \quad = Fe(OH)_2 + H_2 \qquad\qquad 2Fe + 4H_2O \quad = 2Fe(OH)_2 + 2H_2$$
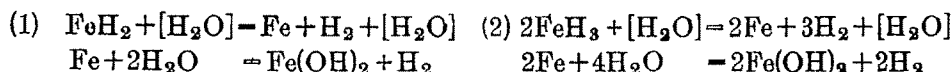
The dissociation pressure of the two hydrides were determined at different temperatures. For this purpose the hydrides were repeatedly washed with dry ether. They were then dried by heating to 25° in a current of hydrogen. The dry hydrides thus obtained still contained traces of magnesium salts as impurities. Measurements of dissociation pressures were repeated several times with different samples of the hydrides, and as the results were reproducible within 2 mm, it was clear that the traces of impurities did not vitiate the results to any great extent.

The apparatus used and the arrangements made have been fully described in the paper on cobalt hydrides (*loc. cit.*).
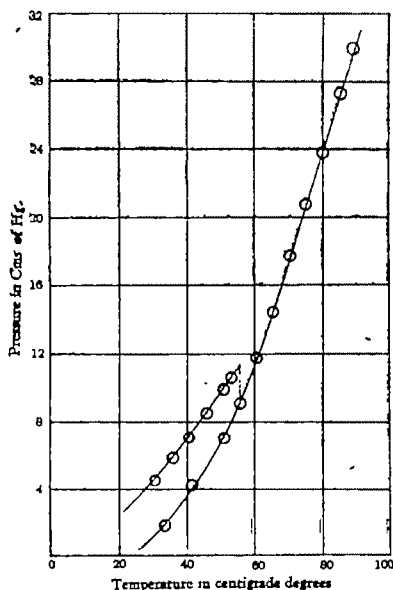
FIG. 1.   FIG. 2.
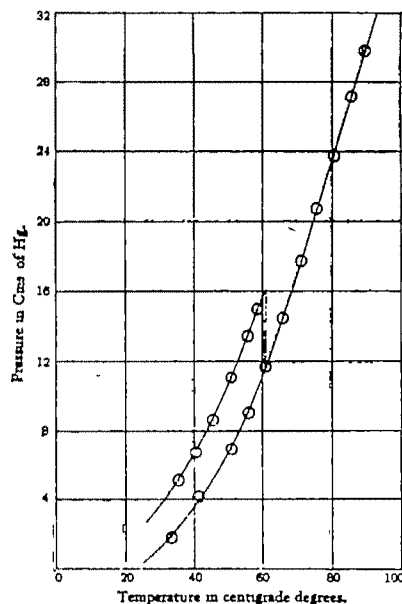
The temperature—dissociation pressure curves shown in Figs. 1 and 2 are the mean of several sets of experiments. In Fig. 1 the upper curve is for FeH_2 which breaks into FeH completely between 53° and 55.6°, the region indicated by the dotted line. The transition point lies in the dotted region. The composition of the second solid phase has been found by analysis and corresponds to the formula FeH.

Similarly in Fig. 2 the upper curve is for FeH_3 which breaks completely into FeH in the dotted region between 58° and 60.2° and the lower curve is for the

2

monohydride FeH which has also been analytically verified. The two lower curves of Figs. 1 and 2 have been found to be exactly one and the same indicating that the two hydrides FeH_2 and FeH_3 break up directly into FeH.

The composition of the second solid phase formed by the decomposition of FeH_2 and FeH_3 has been determined by analysis of the product formed at various temperatures up to 150°. One typical result for each temperature is recorded below.

TABLE III

Starting substance : FeH_2

Temp. of bath.	Wt. of Fe.	Vol. of H_2 (N. T. P). obs.	Vol. of H_2 from hydride.	Ratio Fe/H.	Composition.
70°	0.1238 g.	72.6 c.c.	24.2 c.c.	1 : 0.98	FeH
100	0.0809	47.4	15.8	1 : 0.98	,,
130	0.1610	100.9	33.6	1 : 1.04	,,
150	0.1991	123 0	41.0	1 : 1.03	,,

TABLE IV

Starting substance : FeH_3

Temp. of bath.	Wt. of Fe.	Vol. of H_2 (N. T. P) obs.	Vol. of H_2 from hydride.	Ratio Fe/H.	Composition.
70°	0.1239 g.	74.0 c.c.	24.7 c.c.	1 : 1.01	FeH
100	0.1345	79.5	26.5	1 : 0.99	,,
130	0.1680	103.2	34.4	1 : 1.03	,,
150	0.1145	70.0	23.3	1 : 1.02	,,

It will be seen that the hydride FeH is stable up to 150°. It is not possible to measure the dissociation pressure of the monohydride above 100° on account of difficulty in maintaining the temperature constant within reasonable limits.

The dissociation pressure of the monohydride, FeH, was determined in the following manner : FeH_2 or FeH_3 was decomposed by heating it just above its transition temperature. The hydrogen evolved was removed by a Töpler pump and the substance allowed to cool. The dissociation pressure of this substance was measured at various temperatures starting from the room temperature to about 100°. Several sets of measurements were made and the pressure—temperature graphs were found to be identical in each case. The mean values of the dissociation pressures at particular temperatures for the three hydrides are recorded below.

TABLE V

Compound : FeH_2

Temp.	Press.	$1/T$ (abs)	$\log_{10}p$
30.5°	4.50 cm.	0.003295	0.6532
35 8	5.86	0 003238	0.7679
40.7	7.10	0.003188	0.8513
45.7	8.43	0.003138	0.9258
50.6	9.90	0.003090	0.9956
53.0	10.60	0.003067	1.0253

TABLE VI

Compound : FeH_3

Temp.	Press.	$1/T$ (abs).	$\log_{10}p$.
35 2°	5 20 cm.	0.003245	0.7160
40.4	6 80	0.003191	0.8325
45 3	8.62	0.003142	0.9355
50.8	11 10	0.003088	1.0453
55 8	13.50	0.0C3046	1.1303
58.0	15.05	0 003021	1.1775

TABLE VIII

Compound : FeH

Temp.	Press.	$1/T$(abs).	$\log_{10}p$.	Temp.	Press.	$1/T$(abs).	$\log_{10}p$.
33.3°	1.85 cm.						
41.2	4 20	0 003183	0.6232	70.2°	17.80 cm.	0.002913	1.2504
50.8	7.00	0.003088	0 8451	75.0	20.80	0 002874	1.3181
55.6	9.10	0.003043	0.9590	80 1	23.80	0.002832	1.3766
60.2	11.80	0.003001	1.0719	85 1	27.20	0 002792	1.4346
65.4	14.50	0.002955	1.1614	89 0	29.80	—	—

Iron dihydride is a crystalline, dark grey substance which is fairly stable under ether below 5°. It decomposes in moist air but in dry air the rate of decomposition is slow. It is decomposed quantitatively by water, alcohol or dilute acids. Iron trihydride is a jet black, granular substance. Its other properties are similar to the dihydride. Slight organic impurities are produced during the course of the preparation of these hydrides. The densities of FeH_2 and FeH_3 with respect to ether have been experimentally determined and have been found to be 0.335 at 30° and 0.101 at 25° respectively. Iron monohydride is granular, grey substance and is comparatively stable than the di- and the tribydrides. It is also quantitatively decomposed by dilute acids, water and alcohol.'

In the reactions : $2FeH_2 \rightleftarrows 2Fe + H_2$; $FeH_3 \rightleftarrows FeH + H_2$ and $2FeH \rightleftarrows 2Fe + H_2$, the forward reactions with increasing temperatures take only a few hours to reach the equilibrium at a particular temperature, but the rate of the backward reaction is extremely slow.

The heat of formation of the three hydrides were calculated from the dissociation pressure—temperature data by the help of the Clapeyron—Clausius equation. From Fig. 3 in which $\log_{10} p$ is plotted against $(1/T) \, 10^3$ the values of the heat of formation of the three hydrides were calculated with respect to several points on the three straight lines and the mean values of the heat of formation over a range of temperature from $30°$ to the transition temperature in the case of FeH_2 and FeH_3 and up to about $100°$ for FeH are given below :

FIG. 3.
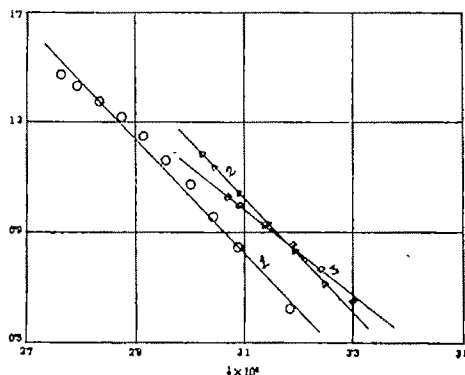
Curves 1—3 refer respectively to
FeH, FeH$_3$ and FeH$_2$.

$$
\begin{aligned}
FeH &= 10{,}770 \text{ cal.} \\
FeH_3 &= 9{,}365 \text{ ,,} \\
FeH_2 &= 7{,}178 \text{ ,,}
\end{aligned}
$$

Further work on these types of compounds is in progress. In conclusion we wish to record our thanks to Dr. P. B. Ganguly and Prof. P. C. Sinha for their kind interest and ungrudging help and to the Vice-Chancellor of the Patna University for a research scholarship to one of us (R. B. N. S.) which enabled him to carry out this work.

COMPLEX COMPOUNDS OF BIGUANIDE WITH TERVALENT METALS
PART XII. *CIS-TRANS* ISOMERISM IN COBALT BIGUANIDE COMPLEXES. DIAMMINO-, HYDROXO-AMMINO-, DIAQUO-, HYDROXO-AQUO-, DIACIDO- AND HYDROXO-ACIDO-COBALTIC *BIS*BIGUANIDINIUM SALTS

BY PRIYADARANJAN RAY AND AMAR NATH MAJUMDAR

A series of basic and normal *trans*-diammino-cobaltic *bis*biguanidinium salts, namely, sulphate, chloride, bromide, iodide and nitrate has been prepared. Deammination and dehydration of these, followed in certain cases by hydrolysis, have led to the production of hydroxo-ammino, hydroxo-acido, hydroxo-aquo, diacido and diaquo cobaltic *bis*biguanidinium salts. Their *trans* configuration has been proved by the action of oxalic acid on the hydroxo-aquo cobaltic *bis*biguanidinium hydroxide of the series. While this hydroxide forms only the corresponding oxalate, the hydroxide of the *cis*-series, previously described by Ray and Ghosh, has been found to give an oxalato-cobaltic *bis*biguanidinium oxalate.

In Part X of this series Ray and Ghosh (*J. Indian Chem. Soc.*, 1942, 19, 1) have described the preparation of a diammino- and a hydroxo-aquo-cobaltic *bis*biguanide complex which were found to possess a *cis* configuration on the basis of their properties and reactions. With a view to obtaining further evidences regarding the configuration of these complexes and to finding out methods for the preparation of their *trans* modification, the present investigation was undertaken. This has led to the isolation of the *trans* modification of a series of disubstituted cobalt *bis*biguanide complexes as described here. *Trans*-diammino-cobaltic *bis*biguanide complex was obtained by a modification of Ray and Ghosh's method for the preparation of the corresponding *cis* compound. This formed the starting substance for the preparation of the rest of the disubstituted *trans* complexes, viz., hydroxo-ammino-, diaquo-, hydroxo-aquo-, diacido- and hydroxo-acido-cobaltic *bis*biguanidinium compounds. The following diagrammatic scheme provides a synopsis of their formation, properties, reactions and inter-relation, as well as that of some of their *cis* modifications, previously described by Ray and Ghosh, for the sake of comparison.

It will be found that by the action of sodium thiosulphate the hydroxo-aquo derivative of both the series ultimately leads to the same product, an insoluble, non-electrolyte binuclear bridge compound, *μ*-thiosulphato-tetrakis *bis*biguanidinium dithiosulphato-dicobalt, already described by Ray and Ghosh (*loc. cit*), which indicates a transformation of the *trans*-hydroxo-aquo complex into its isomeric *cis* form in the presence of H^+ ions.

The configurations of the two series have been definitely proved by the action of oxalic acid on their respective hydroxo-aquo-cobaltic *bis*biguanidinium hydroxide. The *cis* compound gives rise to an oxalato-oxalate, while its *trans* isomer yields only a hydroxo-aquo oxalate as is to be expected.

Cis-Series

$$\left[(NH_3)_2Co(Big\overset{+}{H})_2\right](OH)_3$$

removal of ammonia by air
current in solution

$$\left[(Big)_2Co\diagdown\overset{(OH)}{\underset{(OH)}{}}\diagup(Big)_2\right]$$

dark brown, insoluble.

$$\left[(OH)(H_2O)Co(Big\overset{+}{H})_2\right](OH)_2$$

80°

blue-violet, sparingly soluble

dil. H_2SO_4

NaOH

$$\left[(OH)(H_2O)Co(Big\overset{+}{H}_2)\right]SO_4$$

blue-violet, sparingly
soluble.

oxalic acid

$$\left[(C_2O_4)Co(Big\overset{+}{H})_2\right]_2(C_2O_4)$$

dark violet, sparingly soluble.

$BaCl_2$

$$-\left[(OH)(H_2O)Co(Big\overset{+}{H})_2\right]Cl_2$$

blue-violet soluble.

$Na_2S_2O_3$

$$\left[(OH)(H_2O)Co(Big\overset{+}{H})_2\right]S_2O_3$$

blue-violet, sparingly soluble.

excess $Na_2S_2O_3$

$$\left[\begin{matrix}S_2O_3\\ \overset{}{\underset{+}{}}Co\\ (Big\overset{+}{H})_2\end{matrix}- S_2O_3 - Co\begin{matrix}S_2O_3\\ \\ (Big\overset{+}{H})_2\end{matrix}\right]$$

green, insoluble

Trans-Series

$$\left[(NH_3)_2Co(Big\overset{+}{H})_2\right]\overset{OH}{SO_4(Cl_2)} - NH_3 \text{ at } 90° \longrightarrow \left[(NH_3)(OH)Co(Big\overset{+}{H})_2\right]SO_4(Cl_2)$$

red, sparingly soluble

BaCl$_2$ and
dil. HCl

dil. H$_2$SO$_4$

$-NH_3$ at 100°C

$$\left[(NH_3)_2Co(Big\overset{+}{H})_2\right]Cl_3$$
light rose, very soluble

$$\left[(NH_3)_2Co(Big\overset{+}{H})_2\right]_2(SO_4)_3$$
light rose, very soluble

$$\left[(Big\overset{+}{H})_2\ Co\overset{OH}{\underset{O-}{<}}\right]SO_3''$$

or

$$\left[(OH)(Cl)Co(Big\overset{+}{H})_2\right]Cl$$

$-2NH_3$ at 110°

$-2NH_3$ at 110°

$$\left[Cl_2Co(Big\overset{+}{H})_2\right]Cl$$
rose-red

$$\left[SO_4Co(Big\overset{+}{H})_2\right]_2SO_4$$
rose red

dehydration   hydrolysis in
water

hydrolysis in
water

hydrolysis in
water

$$\left[(H_2O)_2Co(Big\overset{+}{H})_2\right]Cl_3$$

light rose, very soluble.

$$\left[(H_2O)_2Co(Big\overset{+}{H})_2\right]_2(SO_4)_3$$

light rose, very soluble.

$$\left[(OH)(H_2O)Co(Big\overset{+}{H})_2\right]Cl_2(SO_4)$$

red-violet, very soluble.

Ba(OH)$_2$

Na$_2$S$_2$O$_3$
slight ppt.

$$\left[(OH)(H_2O)Co(Big\overset{+}{H})_2\right](OH)_2$$

highly soluble, unstable.

oxalic acid

excess Na$_2$S$_2$O$_3$
and dil. acid

$$\left[(OH)(H_2O)Co(Big\overset{+}{H})_2\right]C_2O_4$$

rose, very soluble.

The individual salts of the *trans*-diammino-*bis*biguanidinium complex exhibit a characteristic difference in their composition. Thus, the chloro-, bromo- and iodo-sulphate of this complex are represented by the formulae,

$$[X] \begin{matrix} Cl \\ SO_4 \end{matrix} , \quad [X]_2 \begin{matrix} Br_4 \\ SO_4 \end{matrix} \quad and \quad [X]_2 \begin{matrix} I_4 \\ SO_4 \end{matrix} ,$$
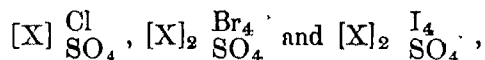
where X stands for the complex ion, $[\ (NH_3)_2Co(Big\overset{+}{H})_2\ ]^{+++}$ and $BigH =$ one molecule of biguanide, $C_2H_7N_5$.

<div align="center">E X P E R I M E N T A L</div>

1.   (a)   *Diammino-cobaltic* bis*Biguandinium Hydroxo-sulphate.*
      (b)   *Hydroxo-ammino-cobaltic* bis*Biguanidinium Sulphate.*
      (c)   *Hydroxo-sulphato-cobaltic* bis*Biguanidinium Sulphate.*

Biguanide sulphate (13.2g.), dissolved in the least quantity (100 c.c.) of 1 : 1 ammonia (6N), was slowly added with stirring to that of 7.2 g. of $CoCl_2.6H_2O$ in the smallest amount (15 c.c.) of water. The mixture, containing the yellow precipitate of cobaltous *bis*biguanidinium sulphate, was transferred to a flask ; about 15 c.c. of liq. ammonia were then added and air was passed through the mixture till the yellow product turned red. The flask was warmed on the water-bath till the precipitate just dissolved. Some unoxidised yellow compound sometimes remained behind. This was filtered off and the filtrate, to which again about 12 c.c. of strong ammonia were added, was left overnight in a refrigerator in a well-stoppered vessel. Red crystals slowly separated from the solution. After 24 hours these were filtered and washed with 1 : 1 ammonia. The product was then recrystallised from warm ammoniacal water, washed first with dilute ammonia, then with alcohol saturated with ammonia gas, and finally dried in air. {Found : N, 38.02, 38.0 ; Co, 13.40, 13.25 ; SO_4, 21.82, 21.37 ; H_2O, 8.09.

$[\ (NH_3)_2Co(Big\overset{+}{H})_2\ ] \begin{matrix} OH \\ SO_4 \end{matrix} .2H_2O$ requires N, 37.84 ; Co, 13.29 ; SO_4, 21.62 ; H_2O, 8.10 per cent}.

The diammino-cobaltic *bis*biguanidinium hydroxosulphate forms red rectangular crystals, sparingly soluble in water. The solution reacts alkaline to litmus.

When heated to 80° the substance loses its water of crystallisation. At 90° one of the ammino groups is removed and at 100° the rest of ammonia is lost. From the dehydrated and deamminated product the whole of SO_4'' is precipitated even in an ice-cold solution, showing that the product obtained by deammination is stable only in the solid state.

The substance dried at 80° to a constant weight gave the following results on analysis. {Found : N, 41.32 ; Co, 14.29.

$\left[\ (NH_3)_2\ Co\ (Big\overset{+}{H})_2\ \right] \begin{matrix} OH \\ SO_4 \end{matrix}$ requires N, 41.17 ; Co, 14.46 per cent}.

The product dried at 90° gave on analysis the following results. {Found : N, 39.13 ; Co, 14.97. $[(NH_3)(OH)Co(Big\overset{+}{H})_2]$ SO_4, hydroxo-ammino-cobaltic *bis*biguanidinium sulphate requires N, 39.39 ; Co, 15 10 per cent}.

The substance dried at 100° to a constant weight gave on analysis :

Co, 15.72. $\left[(Big\overset{+}{H})_2 Co \overset{OH}{\underset{O-}{<}}\right] SO''_3$, hydroxo-sulphato-cobaltic *bis*biguanidinium

sulphate, requires Co, 15.78 per cent}.

Loss in weight suffered by the hydrated diammino-cobaltic *bis*biguanidinium hydroxo-sulphate at different temperatures is given in the following table.

TABLE I

Temp.	Wt. of subs,	Loss in wt.	Loss %.	Loss (calc.).
80° (room temp)	1.4026g.	...	...	...
80	1.3986	0.1040g.	8.09	8.10 (for $2H_2O$)
90	1.2428	0.1603	11.87	11.93 (for $1NH_3$ & $2H_2O$)
100	1.1947	0.2079	15.99	16.22 (for $2NH_3$ & $2H_2O$)

2.   (a) *Diammino-cobaltic* bis*Biguanidinium Hydroxo-chloride.*

(b) *Hydroxo-chloro-cobaltic* bis*Biguanidinium Chloride.*

The diammino-cobaltic *bis*biguanidinium hydroxo-chloride was prepared by the decomposition of the diammino-cobaltic *bis*biguanidinium hydroxo-sulphate with the calculated amount of barium chloride in the form of a saturated solution. On addition of alcohol to the cold filtrate, free from Ba^{++} or SO_4'', the substance was obtained in rose-coloured, needle-shaped crystals. These were filtered, washed free from the mother-liquor with ice-cold water followed by cold alcohol and finally dried in air. The substance was found to be more soluble than the diammino compound. The solution reacts alkaline to litmus. {Found : N, 43.64 ; Cl, 18.32 ; Co, 15.31 ; NH_3, 8.63 (by loss at 80°).

$\left[(NH_3)_2 Co (Big\overset{+}{H})_2\right] \overset{OH}{\underset{Cl_2}{}}$, diammino-cobaltic *bis*biguanidinium hydroxo-chloride, requires N, 43.86 ; Cl, 18.54 ; Co, 15.39 ; NH_3, 8.88 per cent}.

3

When heated to 80° the substance lost both its ammino groups and the product gave the following results on analysis. {Found : Co, 16.80.

$\left[\begin{array}{c} OH \\ Cl \end{array}\hspace{-0.3em}> Co\ (Big\overset{+}{H})_2\ \right]$ Cl, hydroxo-chloro-cobaltic *bis*biguanidinium chloride, requires Co, 16.90 per cent}.

From the deamminated product the whole of the chlorine was precipitated as AgCl even in an ice-cold solution, indicating that the substance is stable only in the solid state.

3. *Diammino-cobaltic* bis*Biguanidinium Hydroxo-nitrate*.—The diammino-cobaltic *bis*biguanidinium hydroxo-sulphate was decomposed by digestion with an equivalent quantity of barium nitrate in the form of a saturated solution. The filtrate, freed from Ba^{++} and SO_4'', was made ammoniacal and cooled with the addition of alcohol. Light rose-coloured, needle-shaped crystals of the hydroxo-nitrate separated from the solution. These were filtered, washed with ice-cold alcohol till free from the mother-liquor, and finally dried in air. The solution of the substance reacts alkaline to litmus.

{Found : N (besides that of NO_3), 36.49 ; Co, 12.68 ; NO_3, 26.80.

$\left[\ (NH_3)_2 Co\ (Big\overset{+}{H})_2\ \right]$ $\begin{array}{c} OH \\ (NO_3)_2 \end{array}$, $1.5H_2O$ requires N (excluding NO_3), 36.28 ; Co, 12.75 ; NO_3, 26.78 per cent}.

4. *Diammino-cobaltic* bis*biguanidinium chloro-sulphate* was obtained as light rose-coloured crystals by treating the diammino-cobaltic *bis*biguanidinium hydroxo-sulphate with ice-cold N-HCl added in drops till the supernatant liquid reacted slightly acidic to litmus. These were filtered and washed free from excess acid with alcohol. The product was purified by recrystallisation from ammoniacal water and subsequently dried in air. The solution of the substance reacts neutral to litmus. {Found : N, 37.52 ; Cl, 7.96 ; Co, 13.23 ; SO_4, 21.58.

$\left[(NH_3)_2 Co(Big\overset{+}{H})_2\ \right]$ $\begin{array}{c} Cl \\ SO_4 \end{array}$, H_2O requires N, 37.84 ; Cl, 7.99 ; Co, 13.27 ; SO_4, 21.60 per cent}.

5. *Diammino-cobaltic* bis*biguanidinium bromo-sulphate* was obtained in the form of red rectangular prisms on cooling a solution of diammino-cobaltic *bis*biguanidinium hydroxo-sulphate mixed with twice its equivalent of ammonium bromide in the least quantity of warm ammoniacal water. The crystals were washed first with cold water, then with cold alcohol and finally dried in air. The substance reacts neutral to litmus. {Found : N, 31.50 ; Br, 30.07 ; Co, 11.06 ; SO_4, 8.90.

$\left[\ (NH_3)_2 Co\ (Big\overset{+}{H})_2\ \right]_2$ $\begin{array}{c} Br_4 \\ SO_4 \end{array}$, $3.5H_2O$ requires N, 31.43 ; Br, 29.99 ; Co, 11.04 ; SO_4, 8.98 per cent}.

6. *Diammino-cobaltic* bis*biguanidinium iodo-sulphate* was prepared in the same way as the above-described bromo-sulphate by using ammonium bromide. It forms red prismatic crystals which are less soluble than those of the corresponding bromo-sulphate. Its solution reacts neutral to litmus. {Found : N,26.49 ; I, 40.09; Co, 9.34 ; SO$_4$, 7.52. $\left[(NH_3)_2 Co (Big\overset{+}{H})_2 \right]_2 \overset{I_4}{SO_4}$, 3.5H$_2$O requires N.26.73 ; I, 40.42 ; Co,9.38 ; SO$_4$ 7.64 per cent}.

Thus the complex bromo and iodo-sulphate differ in composition from the corresponding chloro-sulphate.

7. (a) *Diammino-cobaltic* bis*Biguanidinium Sulphate.*

(b) *Sulphato-cobaltic* bis*Biguanidinium Sulphate.*

The diammino-cobaltic *bis*biguanidinum sulphate was obtained in light rose-coloured prismatic needles by one of the following methods :

(i) By cooling a solution of diammino-cobaltic *bis*biguanidinium hydroxo-sulphate in warm ammonia to which an excess of ammonium sulphate was added. The crystals that separated out were washed with ice-cold water followed by cold alcohol.

(ii) By the neutralisation of a suspension of diammino-cobaltic *bis*biguanidinium hydroxo-sulphate with ice-cold N-H$_2$SO$_4$, added in drops, till the supernatant solution was slightly acidic to litmus.

The product obtained by either of the above methods was purified by recrystallisation from warm ammoniacal water. It was then dried in air. Its solution reacts neutral to litmus. {Found : N, 30.61 ; Co, 10.85 ; SO$_4$, 26.45.

$\left[(NH_3)_2 \overset{.}{C}o(Big\overset{+}{H})_2 \right]_2 (SO_4)_3$, 12H$_2$O requires N,30.71 ; Co, 10.78 ; SO$_4$, 26.33 per cent}.

The substance lost ten molecules of its water of crystallisation on dehydration over lime in an atmosphere of ammonia.

The product, dried at 85° to a constant weight, gave the following results on analysis : N, 38 41 ; Co, 13.39. $\left[(NH_3)_2 Co (Big\overset{+}{H})_2 \right]_2 (SO_4)_3$ requires N, 38.26 ; Co, 13.43 per cent.

When dried to a constant weight at 110° the product lost all its ammonia and gave on analysis Co, 14 48. $\left[(SO_4) Co (Big\overset{+}{H})_2 \right]_2 (SO_4)$, sulphato-cobaltic *bis*biguanidinium sulphate, requires Co, 14.50 per cent.

The whole of the sulphate is precipitated from a cold solution of this dried product showing that the sulphato compound is stable only in the solid state.

The loss in weight suffered by the hydrated diammino-sulphate,

$$\left[(NH_3)_2Co(Big\overset{+}{H})_2 \right]_2 (SO_4)_3, 2H_2O$$ at different temperatures is given in the following table,

TABLE II

Temp	Wt of substance.	Loss of wt.	% Loss.
30° (room temp.)	2.2889g.	...	...
85°	2.2086	0.0802g.	3.6(calc, for $2H_2O = 3.9$)
110°	2.1054	0.1835	7.5(calc. for $2H_2O$ and $2NH_3 = 7.66$)

8. (a) *Diammino-cobaltic* bis *Biguanidinium Chloride.*

    (b) *Dichloro-cobaltic* bis *Biguanidinium Chloride.*

The diammino-cobaltic *bis*biguanidinium chloride was obtained by the decomposition of the diammino-cobaltic *bis*biguanidinium sulphate with the calculated quantity of barium chloride in the form of a saturated solution. The filtrate from barium sulphate on cooling gave light rose-coloured prismatic needles of the substance on addition of alcohol. The crystals were washed free from mother-liquor with cold alcohol and finally dried in air. The solution reacts acid to litmus.

{Found : N, 38.14 ; Cl, 24.39 ; Co, 13.37. $\left[(NH_3)_2Co(Big\overset{+}{H})_2 \right]Cl_3.2H_2O$ requires N, 38.40 ; Cl, 24.34 ; Co, 13.47 per cent}.

The substance on dehydration to a constant weight at 85° gave on analysis :·N, 41.90 ; Co, 14.65. $\left[(NH_3)_2Co(Big\overset{+}{H})_2 \right]Cl_3$ requires N, 41.84 ; Co, 14.68 per cent.

The product obtained by drying to a constant weight at 110° gave on analysis : Co, 15.96. $\left[Cl_2Co(Big\overset{+}{H})_2 \right]Cl$, dichloro-cobaltic *bis*biguanidinium chloride, requires Co, 16.04 per cent. The substance thus lost both its ammonia molecules at 110°.

The whole of the chlorine is precipitated as AgCl from a cold solution of the product dried at 110°, indicating that the dichloro-cobaltic *bis*biguanidinium chloride is stable only in the solid state.

The loss of weight suffered by the hydrated diammino-chloride at different temperatures is given in the following table.

TABLE III

Temp.	Wt. of substance.	Loss in wt.	%Loss.
30° (room temp.)	1.5111 g.	...	...
85°	1.3887	0.1224g.	8.10 (calc. for $2H_2O = 8.23$)
110°	1.1727	0.3384	15.78 (calc. for $2H_2O$ & $2NH_3 = 16.0$)

TABLE IV

Equivalent conductivity of $\left[(NH_3)_2 Co\ (Big\overset{+}{H})_2\right]Cl_3, 2H_2O$ *at* $33 \pm 0.5°$.

Dilution (v)	32	64	128	256	512	1024 litres
Λ_v	123.3	134.9	147.3	158.9	170.2	178.8 in mohs

The values are rather quite high indicating partial hydrolysis into hydroxo-aquo-cobaltic *bis*biguanidinium chloride as shown below :

$$\left[(NH_3)_2 Co\ (Big\overset{+}{H})_2\right]Cl_3 \xrightarrow{2H_2O} \left[(OH)(H_2O) Co\ (Big\overset{+}{H})_2\right]Cl_2 + NH_4Cl + NH_3,$$
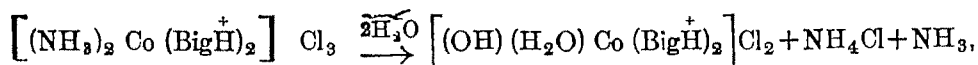
The equivalent conductivity of the substance, if unchanged, would lie near about 120 at infinite dilution like that of KCl.

9. *Diammino-cobaltic* bis*biguanidinium nitrate* was prepared by the decomposition of the corresponding complex sulphate with a saturated solution of barium nitrate. On adding alcohol to the ammoniacal ice-cold filtrate the substance was obtained in the form of light rose-coloured, prismatic needles. These were washed free from mother-liquor with cold alcohol and finally dried in air. Its solution reacts acid to litmus. {Found : N (excluding NO_3), 33.42 ; Co. 11.77 ; NO_3, 37.0.

$\left[(NH_3)_2 Co\ (Big\overset{+}{H})_2\right](NO_3)_3, H_2O$ requires N (excluding NO_3), 33.67 ; Co, 11.81 ; NO_3, 37.27 per cent}.

10. *Hydroxo-aquo-cobaltic* bis*biguanidinium sulphate* separated as red crystals by the addition of alcohol to an ice-cold solution of hydroxo-sulphato-cobaltic *bis*biguanidinium sulphate produced by the dehydration and deammination of diammino-cobaltic *bis*biguanidinium hydroxo-sulphate (*vide supra*).

It is very soluble in water and the solution reacts alkaline to litmus. The corresponding *cis*-isomer (*cf.* Rây and Ghosh, *loc. cit.*), on the other hand, like its chromium analogue, hydroxo-aquo-chromium *bis*biguanidinium sulphate (Rây and Saha. *J. Indian Chem. Soc.*, 1938, **15**, 353), is blue-violet in colour and sparingly soluble in water.

{Found : Co, 13.65 ; SO$_4$, 22.39. $\left[(OH)\,(H_2O)\,Co\,(Big\overset{+}{H})_2\right]$ SO$_4$, 2H$_2$O requires Co, 13.77 ; SO$_4$, 22.43 per cent}.

11. *Hydroxo-aquo-cobaltic* bis*biguanidinium chloride* was obtained in red violet needle-shaped crystals by one of the following methods :

(*i*) By slow evaporation in air of the filtrate from the decomposition of diammino-cobaltic *bis*biguanidinium hydroxo-sulphate with barium chloride solution.

(*ii*) By recrystallisation from water of hydroxo-chloro-cobaltic *bis*biguanidinium chloride produced by the deammination of diammino-cobaltic *bis*biguanidinium hydroxo-chloride by heat.

The product obtained by either of the above methods was purified by recrystallisation from warm water. The solution of the substance reacts alkaline to litmus. {Found : N, 36.39 ; Cl, 18.30 ; Co, 15.17 ; H$_2$O, 9.24.

$\left[(OH)\,(H_2O)\,Co\,(Big\overset{+}{H})_2\right]$ Cl$_2$, H$_2$O requires N, 36.37 ; Cl, 18.44 ; Co, 15.31 ; H$_2$O, 9.35 per cent}.

The substance, when dried to a constant weight at 80°, loses all the water molecules and forms hydroxo-chloro-cobaltic *bis*biguanidinium chloride, described above. (Found for the dried product : Co, 16 73. Calc. Co, 16 90 per cent).

By heating to 20°, therefore, not only the water of hydration but also that bound inside the complex zone is lost.

12. *Diaquo-cobaltic* bis*biguanidinium sulphate* was obtained in the form of light rose-coloured prismatic needles by the addition of alcohol to an ice-cold solution of sulphato-cobaltic *bis*biguanidinium sulphate, obtained by the deammination of diammino-cobaltic *bis*biguanidinium sulphate (*vide supra*). It is very soluble in water and the solution reacts neutral to litmus. {Found : Co, 13.42 ; SO$_4$ 32.98.

$\left[(H_2O)_2\,Co\,(Big\overset{+}{H})_2\right]_2$ (SO$_4$)$_3$ requires Co, 13.37 ; SO$_4$ 32.65 per cent}.

13. *Diaquo cobaltic* bis*biguanidinium chloride* was obtained as a red crystalline precipitate by passing dry HCl gas through an ice-cold saturated solution of dichloro cobaltic *bis*biguanidinium chloride, obtained by the deammination of diammino cobaltic *bis*biguanidinium chloride (*vide supra*). The passage of HCl gas should be stopped in time to prevent the decomposition of the substance. The product was filtered, washed free from HCl with cold alcohol and dried in air. The substance is very soluble in water and the solution reacts neutral to litmus. {Found : Cl, 26.13 ; Co, 14 61 ; H$_2$O (by loss at 110°), 8.79.

$\left[(H_2O)_2\,Co\,(Big\overset{+}{H})_2\right]$ Cl$_3$ requires Cl, 26.39 ; Co, 14.61 ; H$_2$O, 8.92 per cent}.

14. *Oxalato-co'altic* bis*Biguanidinium Oxalate* (cis).—The hydroxo-aquo-cobaltic *bis*biguanidinium hydroxide hydrate, described by Ray and Ghosh (*loc. cit.*), was neutralised by digestion with oxalic acid solution, added dropwise, till the supernatant liquid became slightly acidic to litmus. The sparingly soluble dark violet base

changed into the bluish violet prismatic needle-shaped crystals of the oxalate. The crystals were filtered, washed free from excess of oxalic acid with alcohol and finally dried in air. The substance is practically insoluble in water. {Found : Co, 13.60 ; C_2O_4, 30.52 ; H_2O (by loss at 95°), 8.41.

$$\left[C_2O_4.\ Co\ (Big\overset{+}{H})_2\right]_2\ (C_2O_4),\ 4H_2O$$ requires Co, 13.74 ; C_2O_4, 30.77 ; H_2O, 8.39 per cent}.

The product obtained by drying to a constant weight at 95° gave on analysis : Co, 14.90 ; C_2O_4, 33.41. $\left[C_2O_4.\ Co\ (Big\overset{+}{H})_2\right]_2\ (C_2O_4)$ requires Co, 15.0 ; C_2O_4, 33.59 per cent}.

15. *Hydroxo-aquo cobaltic* bis*Biguanidinium Oxalate* (trans).—*Trans* hydroxo-aquo-cobaltic *bis*biguanidinium hydroxide was obtained by the decomposition of the *trans*-hydroxo-aquo-cobaltic *bis*biguanidinium sulphate (*vide supra*) with the calculated amount of baryta solution. To the filtrate from barium sulphate, freed from Ba^{++} or SO_4'', a slight excess of oxalic acid was added in the form of a concentrated solution. The solution was then cooled in ice and treated with cold alcohol. The hydroxo-aquo-cobaltic *bis*biguanidinium oxalate separated in fine rose-coloured needle-shaped prismatic crystals. These were filtered, washed free from excess of oxalic acid with cold alcohol and finally dried in air. The substance is very soluble in water and the solution reacts acid to litmus. {Found : Co, 12.89 ; C_2O_4, 18.93.

$$\left[(OH)\ (H_2O)\ Co\ (Big\overset{+}{H})_2\right]\ C_2O_4,\ 4H_2O$$ requires Co, 12.93 ; C_2O_4, 19.30 per cent}.

It might be of interest to mention here that an attempt to prepare the hydroxo-aquo-cobaltic *bis*biguanidinium hydroxide of the *trans* series from the corresponding chloride by treatment with moist silver oxide gave rise to an insoluble product and the filtrate was found absolutely free from all cobalt. This can be accounted for as follows :

Either, during the treatment with Ag_2O geometrical inversion occurs and the *trans*-hydroxide, first formed, immediately changes into the insoluble *cis*-isomer, or, the *trans*-base, first produced, unites with AgCl or excess of Ag_2O giving rise to the formation of a secondary complex which can be represented as
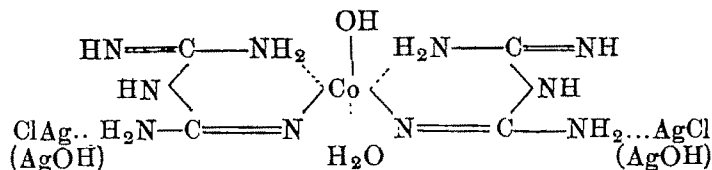
This can be compared with the monammine of AgCl ; the larger volume of the co-ordinating group (*i.e.*, cobalt *bis*biguanide group) probably lowers the co-ordination number of silver, if we assume the chlorine or hydroxyl to be ionisable. Alternatively, it may be regarded as a non-ionisable compound with co-ordination number of silver equal to 2 as usual. Similar compounds were described by Ray

and Siddhanta with cobalt and chromium *tris*biguanidinium hydroxides (*J. Indian Chem. Soc.*, 1941, **18**, 298).

A solution of diammino-cobaltic *bis*biguanidinium chloride gives precipitates of characteristic colour with many complex anions as described below.

1. Potassium ferrocyanide
   $K_4Fe(CN)_6$ — A cream coloured precipitate which turns buff on boiling and finally decomposes giving a red product.

2. Potassium ferricyanide
   $K_3Fe(CN)_6$ — A light green precipitate soluble in mineral acids, turns buff on boiling and becomes finally red

3. Potassium cobalticyanide
   $K_3Co(CN)_6$ — A light rose precipitate, soluble in acids.

4. Potassium chromate
   K_2CrO_4 — Light orange precipitate soluble in mineral acids.

5. Potassium mercuri-iodide
   K_2HgI_4 — A light rose precipitate soluble in hot water but reappears on cooling.

6. Potassium bismuthi-iodide
   $KBiI_4$ — A yellowish orange precipitate, insoluble in mineral acids but soluble in KI.

Hydroxo-aquo and diaquo-cobaltic *bis*biguanidinium chlorides give similar precipitates with the abovo-mentioned reagents.

THE RELATIVE VAPOUR PRESSURE AND MOISTURE CONTENT OF ACTIVATED ALUMINA AND SILICA

By Amar Nath Puri, Balwant Rai and M. A. Rahman

The moisture absorption capacity of a number of activated alumina, silica and ferric oxide samples prepared in different compounds has been studied. The materials were found to vary appreciably in their "Activity". Explanation has been offered for such differences.

Evidence is brought forth from these results regarding the mechanism of moisture absorption by alumina and silica in particular and by soils in general.

In comparatively recent years considerable literature has sprung up on the methods of preparation and utilisation of activated alumina and silica as absorbents for water and other vapours. It is believed that the vapours condense on the surface of these absorbents and are held in minute capillaries formed in the interestices between the alumina and silica particles. The pore size is determined by the size distribution of the particles formed during the precipitation of alumina and silica. The mode of preparation and subsequent treatments such as drying to different extents before washing, etc. have therefore a profound influence on material of this nature.

Among the earliest methods of preparing activated silica is that due to Patrick, Frazer and Rush (*J. Phys. Chem.*, 1927, **31**, 1511). Holmes and Anderson (*Ind. Eng. Chem.*, 1925, **17**, 280) prepared a porous silica gel by adding ferric chloride (instead of HCl) to sodium silicate solution, drying the gel so obtained to a moisture content of 55-60% and then removing the iron oxide from the firm solid by treating with acid. In the same way Holmes prepared other metallic oxide gels, *e. g.* alumina, calcium oxide, chromic oxide, copper oxide and nickel oxide, the oxides being removed as before. Although the same chemical compound, namely SiO_2, was obtained in each case, the various samples had different adsorption capacity for different gases and vapours ; furthermore, no single sample was found consistently to be the best adsorbent for all vapours. Holmes, Sullivan and Metcalf (*Ind. Eng. Chem.*, 1926, **18**, 386) in a later publication showed that the rate of drying had a decided influence on the quality of the product ; the slower the rate, the better was the product. Holmes and Elder (*J. Phys. Chem.*, 1931, **35**, 82) found that an increase in the temperature of the acid treatment of the gel (in order to wash away the metallic oxides) from 30° to 100° increased its porosity.

A good deal of attention has also been paid to the preparation of activated alumina. The usual commercial product manufactured by the Aluminium Co. of America is prepared by dehydrating a crystalline hydrate which is a by-product of their process for the extraction of aluminium.

Adkins (*J. Amer. Chem. Soc.*, 1922, **44**, 2175) prepared activated alumina by the hydrolysis of aluminium methoxide, ethoxide, propioxide, *iso*propioxide and butoxide and used them for decarboxylation and dehydration purposes. Chowdhury

and Bagchi (*J. Indian Chem. Soc.*, 1928, **5**, 111)   prepared alumina gel as a desulphurising agent in petroleum refining by precipitating aluminium hydroxide by the slow addition of ammonia under vigorous stirring to a solution of aluminium sulphate or aluminium chloride, the temperature not exceeding 25°. The gel was washed, dried in an air oven at 60-70° and activated by ignition. Perry (*J. Phys. Chem.*, 1925, **29**, 1462) prepared alumina from aluminium sulphate by treating the latter with ammonia and studied its adsorption capacity towards various vapours after activating it by passing dry air heated to 200° over it.

The main difficulty about assessing the value of a particular preparation lies firstly in the fact that the mechanism of adsorption or activation is not fully understood, secondly there is no uniform standard of comparison. A good deal of light has been thrown on the mechanism of moisture absorption by soils by the recent work of Puri and co-workers (Puri and Crowther, *Pro. Roy. Soc.*, 1924, A, **106**, 232). The evidence adduced is overwhelmingly in favour of the hypothesis that moisture is absorbed in the ·minute capillaries formed by the intersticial spaces between the particles. From the known relationship between the diameter of capillaries and the reduction in the vapour pressure of the water held in them, it is possible to calculate the size distribution of the capillaries as well as of the particles forming those capillaries. Moisture absorption from atmospheres of different humidities therefore affords an elegent method of comparing the absorption properties of activated silica and alumina.

In the present work, a number of alumina and silica gels was prepared by the various methods in vogue and then treated and activated in different ways. The size distribution of the pore spaces in the samples of alumina and silica was determined by studying their moisture absorption from atmospheres of different humidities. These observations, it was presumed, would give a measure of the activity of different samples.

E X P E R I M E N T A L

Moisture Absorption by Samples of Activated Alumina.

Preparation of the Material. (*i*) *From Aluminium amalgam.*—Alumina from aluminium amalgam was prepared in the manner described by Adkins (*loc. cit.*). The amalgam was prepared by covering fine strips of · pure aluminium cut from thin sheets with ½% solution of mercuric chloride for 1½ minute and subsequent washing. After the completion of reaction between the amalgam and water, the precipitated alumina was collected on a filter paper, washed and then dried at 60-70° as recommended by Chowdhury and Bagchi (*loc. cit.*).

(*ii*) *From Aluminium Nitrate.*—The aluminium nitrate was calcined on an ordinary burner until no more red fumes were given out. The resulting pure white solid passed through a 200 mesh sieve with a little grinding and gave no test for nitrate.

(*iii*) *By Precipitation from* AlCl$_3$, Al$_2$(SO$_4$)$_3$, *Potash alum and Soda alum.*—Aluminium hydroxide was obtained in every case as a flocculent gelatinous precipitate by the slow addition of ammonia with vigorous stirring to the salt solution keeping the temperature below 25°, as Chowdhury and others (*loc. cit.*) have reported that higher temperatures yield comparatively poor absorbents. The precipitate in every case was washed free from impurities and was ultimately dried in an air oven at 60-70°.

The various samples of alumina were then activated at 200° in a stream of of carbon dioxide for 2 hours.

Moisture Absorption by Activated Alumina at different Humidities.—Sulphuric acid—water mixtures corresponding to different humidities were prepared. About 2g. of the various samples, accurately weighed, were kept in crucibles and placed in vacuum disiccators containing the different sulphuric acid—water mixtures. The increase in weight of the samples was determined after two days as in preliminary experiments it was found that the maximum moisture absorption from atmosphere of a particular humidity takes place within this time.

Fig. 1.

Moisture absorption-curves of activated alumina samples as compared with soil No. P. O. 13.
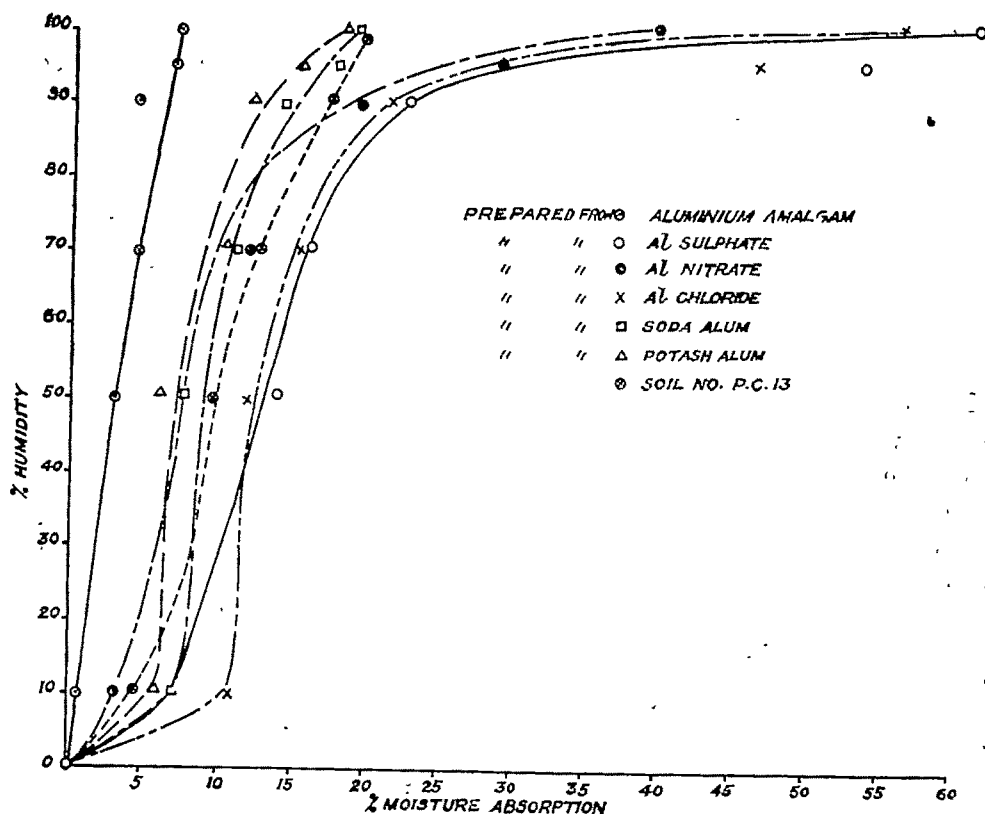
The results of moisture absorption by various samples of activated alumina at different humidities are given in Table I and plotted in Fig. 1.

TABLE I

Moisture absorption of various samples of alumina as compared with soil No. P. C. 13 from different humidities.

Allumina prep- pared from	% Moisture absorbed from different humidities					
	10%	50%	70%	90%	95%	99%
1. Al-amalgam	0.8	3.2	4.5	4.5	6.9	7.08
2. $Al_2(SO_4)_3$	7.1	14.05	16.1	23.9	53 5	62.0
3. $Al(NO_3)_3$	3.17	7.7	12.0	19.4	28.8	40.4
4. $AlCl_3$	11.1	13.5	15.6	21.6	48.0	57.8
5. Soda alum	6 9	7.5	11.1	12.3	19.1	19.1
6. Potash alum	6 2	6.2	10.7	12.0	15.8	18.9
Soil No. P. C. 13	4.81	9 33	11.78	...	16.8	19.57

It is seen that the samples of alumina prepared by precipitating from $AlCl_3$ and $Al_2(SO_4)_3$ absorb moisture to nearly the same extent at any given humidity. The alumina prepared by calcining $Al(NO_3)_3$ absorbs much less moisture from atmospheres of lower humidities but at higher humidities the moisture absorption increases though it does not equal the amount absorbed by the other two samples already referred to. This shows that most of the capillaries in this sample are of comparatively large size. This is probably due to the elimination of NO_2 gas during the calcination of $Al(NO_3)_3$. Continuous elimination of NO_2 and O_2 would leave larger gaps and spaces in between the molecules of alumina.

The samples prepared by precipitating from soda alum and potash alum absorb moisture nearly to the same extent as the one prepared from $Al_2(SO_4)_3$ at 10% humidity but with increase in humidity the difference in their moisture absorption capacity goes on increasing, the amount absorbed by the latter sample becoming ultimately far in excess of the others. This is because the elimination of K_2SO_4 and Na_2SO_4 from potash and sodium alums leaves behind much larger pore spaces which cannot effectively absorb moisture from the vapour phase. It is also worth noting that these two samples, prepared from alum, resemble each other in absorbing the same amount of moisture at all humidities. The sample prepared from aluminium amalgam absorbs very little moisture even from fully saturated atmosphere.

These results very clearly show that in the preparation of activated alumina, the method of preparation and the composition of the starting material are of great importance. Further, the total capillary space in an activated material is not the only consideration. In fact, the size of the capillaries is a much more important factor. The alumina prepared, for instance, from potash alum or by heating $Al(NO_3)_3$ will have larger capillary spaces on account of the elimination of larger molecules, but at the same time the size of the capillaries will be too big for effective moisture absorption from the vapour phase.

The moisture absorption curve for a soil sample at different humidities is also included in Fig. 1. The similarity between the soil and alumina curves is very striking. In both cases the curve between 10 and 70% humidity forms a straight line. The slope of this line seems to be characteristic for a particular type of the sample *i.e.* it defines the hygroscopic nature of the material, just as in soils (Puri, *Soil Sci.*, 1932, **33**, 405) and may be regarded as hygroscopicity of the sample from analogy with soils. Beyond 70% humidity the curves tend to become asymtotic. At humidities varying from 0 to 10% the curve has the least slope.

Absorption of Organic Vapours by the various Alumina Samples.— Evidence regarding the difference in capillary sizes of the various alumina samples was also obtained by determining their absorption of organic vapours. Holmes (*loc. cit.*) has shown that there is an optimum capillary size for each vapour to get absorbed. If this is so, the vapours of liquids with larger melecules will require correspondingly larger capillary spaces and *vice versa*. In other words the alumina prepared by heating $Al(NO_3)_3$ would absorb preferentially larger molecules and those prepared from $AlCl_3$ and $Al_2(SO_4)_3$ by precipitation would preferentially absorb smaller molecules. The results are given in Table II.

TABLE II

Adsorption of organic vapours by different alumina samples (activated).

Alumina prepared from	Vapours absorbed (%)						
	Benzene.	Toluene.	Xylene.	$CHCl_3$.	CCl_4.	AcOCl.	Ph.COCl.
1. $Al_2(SO_4)_3$	12.0	55.5	39.4	33.1	36.2	54 9	74.1
2. Al $(NO_3)_3$	3.5	17.9	15.6	15.0	13.0	19.9	38 5
Ratio : % vapour adsorbed by 1 to % of that absorbed by 2.	0.29	0.32	0.39	0.45	0.36	0.36	0.52

It is seen that as the size of the molecule increases, the ratio of vapour adsorbed by alumina prepared from aluminium nitrate to that adsorbed by the one prepared from $Al_2(SO_4)_3$ goes on increasing.

*Titration Curves of Alumina Samples.—*Three samples of alumina namely those prepared (*i*) by calcining $Al(NO_3)_3$, (*ii*) by precipitating from aluminium amalgam, and (*iii*) by precipitating from $Al_2(SO_4)_3$ were selected. To 0·1 g. portions of these samples increasing amounts of $N/10$-NaOH or HCl were added and the total volume was made 10 c.c. by the addition of water. The pH values were taken after shaking the suspensions for 48 hours. The results are plotted in Fig. 2.

It is seen that the buffer capacity of the alumina prepared from $Al_2(SO_4)_3$ is the greatest both towards acid and alkali and that of the alumina prepared from the amalgam is the least. This is in accordance with the moisture absorption observa-

Fig. 2.

Titration curves for activated alumina samples with HCl and NaOH.
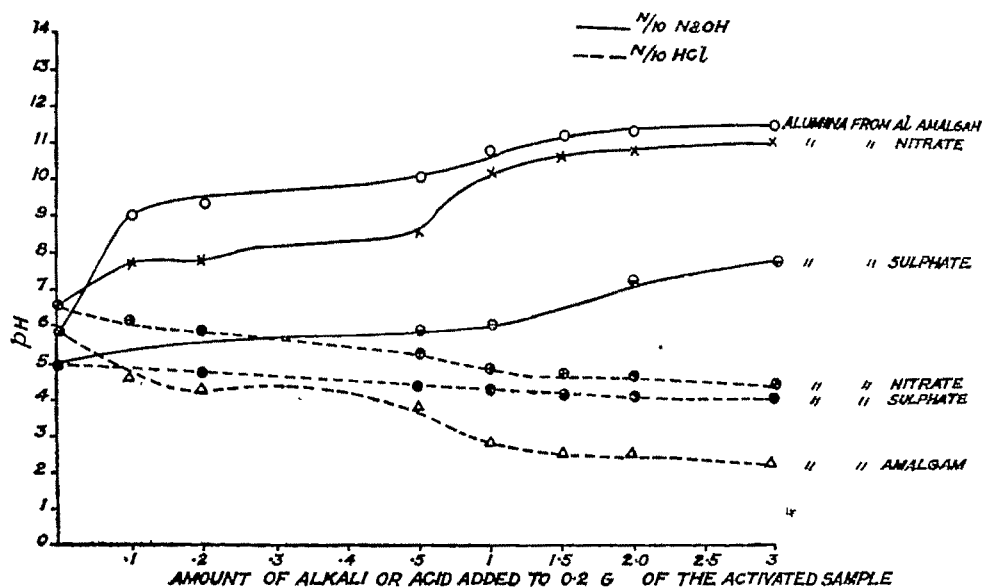
tions of these samples recorded in Table I and discussed before. It is a remarkable fact that although in each case we are dealing with the same chemical compound, yet in each case it has different quantity of acidity as well as alkalinity.

Moisture Absorption by Activated Silica Samples prepared by different Methods.

Silica samples were prepared by various methods and their moisture absorption capacities at different humidities were compared,

The actual methods used in the preparation of these materials are outlined below :

1. *Patrick's Method.*—The silica was obtained by mixing with continuous stirring a hot solution (50°) of HCl containing 10% by weight of the gas with an equal volume of sodium silicate solution of density 1.185. The mixture set to a gel in about an hour's time. It was then broken up into small lumps and washed free from salts, etc and then allowed to dry slowly at the room temperature. The dried lumps were ground to pass 200 mesh, and then activated.

2. *Holme's Method.*—Five samples of silica were obtained by this method. They were prepared from mixtures of different metallic oxide-silica gels, precipitated in the first instance by the addition of different salt solutions to solutions of sodium silicate. Ferric oxide—silica gel mixture, for instance, was formed by slow addition with violent stirring of 2 litres of $2N$-$FeCl_3$ solution to 625 c.c of sodium silicate solution (sp. gravity 1.375) which had previously been diluted with 12.5 litres of water. The mixture was allowed to stand for 60 hours and then filtered through

a fine muslin. The gelatinous mass was allowed to stand in a layer about 5 cm. deep for a few days till it could be handled, and was then broken up into uniform lumps about 2 cm. in diameter. When the water content of the lumps fell to about 50-60%, which required nearly a fortnight, the whole mass was kept in a bottle to prevent evaporation and allowed to "sweat" for a week. The mass consisting of the hydrous oxides of both iron and silicon was then subjected to steam for one hour and then heated to 80° with $9N\text{-}H_2SO_4$, a process which dissolved the iron oxide. Repeated washings were then made to remove the iron and excess acid, after which the gel was dried at approximately 150° for 8 hours. It was then reduced to 200 mesh and activated.

In a similar way gel containing oxides of chromium, copper, cobalt and nickel, mixed with silica were prepared by adding 500 c.c. of $0\cdot22N$ solutions of the metallic chlorides to 50 c.c. of water glass solutions (d, 1.375) diluted to one litre. The gels were then dried, steamed, treated with acid, washed, dried and activated just as described above.

3. *Bartel and Fue's Method.*—A high grade of water glass was diluted to a sp. gravity of 1·025 and neutralised with 1 : 1 HCl (Bartel and Almy, *J. Phys. Chem.*, 1932, **36**, 475). Before the mixture had set to a gel, saturated nickel nitrate solution was added in the proportion of 200 c.c. nickel nitrate to 1000 c.c. of silicic acid solution. The mixture very soon set to a solid green gel and was allowed to synerize at 90°, till the gel seemed to be thoroughly dried. It was then washed with dilute HCl, until the filtrate no longer gave test for Ni with dimethyl glyoxime. It was then heated at 250° in a beaker for two hours, and poured immediately after in cold distilled water. This last treatment, which was repeated several times, caused larger granules to split apart and aided in removing the remaining traces of HCl. The gel was finally dried at 200° and then powdered to 200 mesh and activated.

4. *Silica precipitated by the addition of Ammonium Salts.*—1 Lb. of sodium silicate solution of sp. gravity 1·2 was diluted with equal volume of water and to this 0·8735 equivalent of the ammonium salt, dissolved in 3 litres of water, was added. The resulting gel was broken up into small lumps of 2″ size. after it had set for 24 hours, and washed with hot water to remove ammonium salts.

Seven samples of silica were obtained by this method, using NH_4Cl, $(NH_4)_2SO_4$, NH_4NO_3, $(NH_4)_2CO_3$, $(NH_4)_2CrO_4$, CH_3COONH_4, and ammonium tartrate, as precipitants.

5. *Silica from fused Sodium Silicate.*—Fused sodium silicate (20 g) was boiled with 450 c.c. of $8N\text{-}H_2SO_4$ for two hours and after washing, the precipitate was dried at 150° and then activated.

Activation of Silica Samples.—The usual method of activating silica consists in passing air continuously over the sample heated to 200° for about 2 hours. It was thought of interest to activate some of the samples by passing CO_2, instead of air, and to compare the activity of air-activated and CO_2-activated samples with each other. The results of these experiments are given in Table III

TABLE III

*Comparison of moisture absorption by silica samples
activated in air or CO_2.*

| Silica prepared by | Moisture absorption (%) at humidities | | | | | |
	10%	50%	70%	90%	95%	98.7%
1. Bartel & Fue method						
Air activated	13.9	15.0	25.2	48.1	71.0	80.0
CO_2 ,,	20.8	26.0	27.2	48.8	74.0	90.0
2. Patrick gel						
Air activated	23.7	23.7	34.7	42.6	59.0	59.0
CO_2 ,,	30.2	30.2	34.6	45.0	64.5	66.5
3. Silica prepared from fused sodium silicate.						
CO_2 activated.	12.0	13.9	15 5	21.7	38.1	38.1
Air activated.	5 6	5.6	5.6	9 5	33.1	33.1

It is seen that CO_2-activated samples absorb more moisture than the air activated ones practically at all humidities. It appears that passage of CO_2 over heated silica is more effective in the removal of residual moisture during the process of activation than air. Activation in CO_2 therefore appears to be an advantage and for this reason the rest of the samples were activated in CO_2 only.

Moisture Absorption of Activated Silicia at various Humidities.—Various samples of silica, activated in CO_2. were then taken and their moisture absorption curves determined by noting the increase in weight produced when they were kept over atmospheres of different humidities. The results are given in Table IV and plotted in Fig. 3.

TABLE IV

*Moisture absorption by various activated silica samples
prepared in different ways.*

| Description of the samples. | Absorption of moisture (%) at humidities | | | | | |
	10%	50%	70%	90%	98%	99%
1. Patrick's gel	30.2	30.2	34.6	45.0	64.5	66.5
2. Holmes' gel obtained by mixing sodium silicate solution with :—						
a. $FeCl_3$	6.6	68.2	39 8	44.0	65.8	72.2
b. Chromium chloride	6.3	28.4	28 4	62.6	62.6	67.4
c. Cobalt chloride	5.9	35.8	38.0	63 6	64.4	70.4
d. Nickel chloride	5.6	36.5	38.0	50.8	71.6	86.3
3. Bartel and Fue gel	20.8	26.0	27.2	48.8	74.0	90.0
4. From fused sod. silicate	12.0	13.9	15.5	21.7	38.1	38.1
5. NH_4Cl + sod. silicate	3.8	4.9	11.4	52.6	52.8	54.4
6. $(NH_4)_2SO_4$ + ,,	5.5	8.9	17.6	69.6	69.6	71.0
7. NH_4NO_3 + ,,	5.4	8.5	16.1	52.1	52.1	52.1
8. Amm. carbonate + ,,	8.7	10.9	14.5	46.0	48 0	51.3
9. Amm. oxalate + ,,	3.5	5.6	16.8	52.0	53 0	58.0
10. Amm. tartrate + ,,	5.2	8.2	15 5	54.4	54.6	57.3
11. Amm. chromate + ,,	1 0	3.6	18.5	40.2	40.2	43.0

These results give a clear concept of the comparative size of the capillary spaces of the various samples. At low humidities Patrick's silica gives the maximum moisture absorption. The various types of Holme's silica, as these are prepared from different metallic oxide-silica gels after dissolution of the metallic oxides, have wider capillaries and therefore absorb more moisture from atmospheres of higher humidities. At about 70% humidity the curves for these samples cross the curve for Patrick's silica gel (Fig. 3) and at all humidities lower than 70% Patrick's silica gel absorbs more moisture than do Holme's samples and at all humidities

Fig. 3.

Moisture absorption curves of activated silica gels prepared by diff. methods
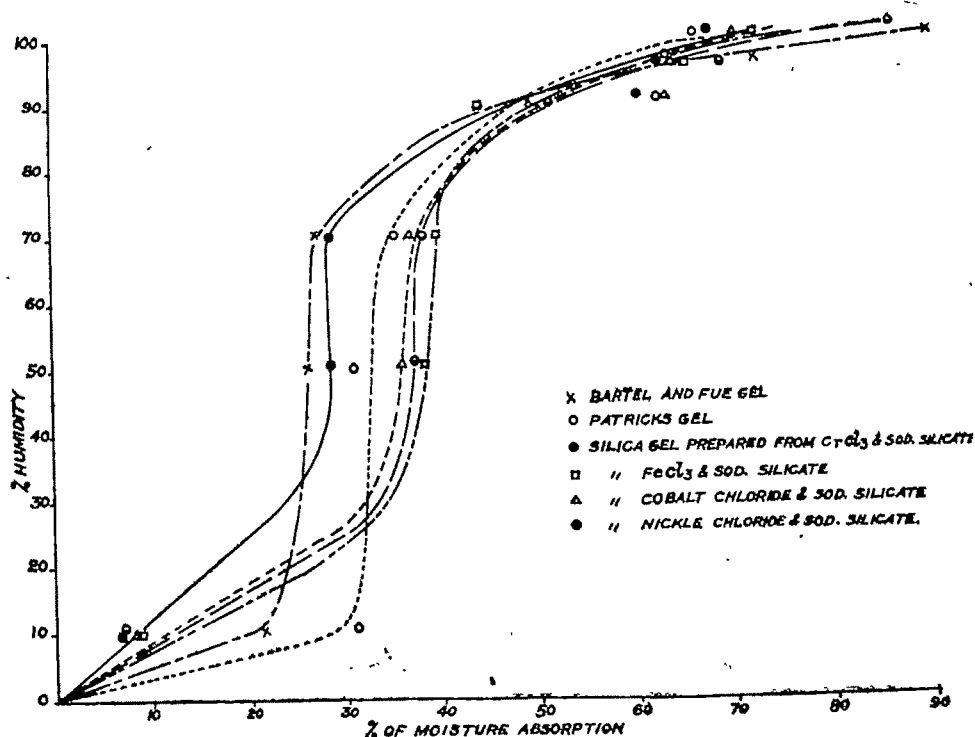
higher than 70% Holmes' samples are better absorbents. In this connection it may be mentioned that Holmes and his co-workers claim better adsorption capacity for their samples. This is because they determined adsorption of benzene and other organic vapours from fully saturated atmospheres and concluded that their samples were superior to the Patrick's sample. The dissolution of metallic oxides from metallic oxide-silica gel, originally prepared by Holmes method, would no doubt leave the resulting silica more porous, but it also results in widening the capillaries and thus making the samples poor absorbents of moisture and other vapours from atmospheres of lower vapour pressure. Patrick's silica, in fact, is superior to Holmes' samples, if absorption is to take place from atmosphere of lower vapour pressures and the claim of Holmes, *etc.* that their sample is a better adsorbent is true only when absorption is to take place from saturated or nearly saturated atmospheres. It is also clear that Patrick's silica as an efficient drying agent

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is superior to that of Holmes, but the latter is more effective if only partial drying is aimed at.

Bartel and Fue's silica also compares favourably with Holmes' silica obtained from nickel oxide-silica gel with which it resembles in the method of preparation, as it absorbs comparatively much moisture at all humidities excepting 50 to 70%.

The silica sample prepared by treating fused sodium silicate with H_2SO_4 is seen to be a poor absorbent at all humidities except at 10%.

The similarity in moisture absorption of the various forms of silica prepared by the addition of ammonium salt solutions to sodium silicate solution is striking and is just to be expected, since in each case the precipitation of silica involves the same chemical reaction. At lower humidities they absorb very little moisture but with increase in humidity the moisture absorption increases and the values at higher humidities are nearer although at no point they become equal to those for Holme's and Patrick's samples. It appears that liberation of ammonia gas from the unstable ammonium silicate first formed, leads to widening of the capillaries and thus lowering of their moisture absorption capacity from the vapour phase at low humidities.

Effect of Grinding on the Activity of Silica Samples.—Two samples of silica were prepared by precipitating them from sodium silicate by the addition of NH_4NO_3 and $(NH_4)_2 SO_4$. In each case one portion of the sample was ground to pass through 200 mesh and another portion was not ground at all but was activated in the form of lumps, each lump being nearly 5 mm. in diameter. The results are given in Table V.

TABLE   V

Effect of powdering on the moisture absorption properties of silica.

Silica prepared from	Moisture absorption (%) at different humidities					
	10%	50%	70%	90%	96%	99%
1. Am sulphate + sodium silicate						
Lumps	5.5	8.9	17.6	69.6	69.6	71.0
Powder	3.8	8.3	15.7	59.8	59.8	59.8
2. Am. nitrate + sodium silicate.						
Lumps	10.0	18.2	23.4	61.7	61.7	61.7
Powder	5.4	8.5	16.1	52.1	52.1	52.1

The results show that lumps possess slightly better absorption capacity at all humidities. This shows that unless it is required for some particular purpose the silica need not or, in fact, should not be powdered, as it results in a sight decrease in its moisture absorption capacity. Grinding, it appears, breaks down some of the finer capillary walls thereby adversely affecting its vapour absorption property.

These results also reveal incidentally that water absorbed by silica. or at least a considerable portion of it, is not due to any chemical combination between silica and water, *i. e.* water is not absorbed as water of hydration, because, if that were so, moisture absorption in either case of lumps or powdered form should have been the same, or perhaps even slightly more so in the case of the powered sample on account of comparatively large surface exposed by it. It appears, therefore, quite certain that almost entire amount of moisture absorbed by silica is held in its capillary micropores.

Moisture Absorption of Ferro-alumino Silicates before and after Activation.

Ferro-alumino silicates, prepared by the addition of mixtures of ferric and aluminium chlorides solution to sodium silicate solution have been shown to be allied to soils in various phsico-chemical properties including moisture absorption at various humidities (Puri, Balwant Rai and Verma, *Soil Sci.*, 1944, 58, 209). Holmes prepared Fe_2O_3. SiO_2 gel by a similar method, namely by the addition of ferric chloride to sodium silicate solution and showed it to be better adsorbent than Patrick's silica gel, and found further that dissolution of ferric oxide by acid left behind a still better adsorbent SiO_2 gel.

The results of moisture absorption of activated and unactivated ferro-alumino silicates of different compositon are given in Table VI and they clearly show that activation is a distinct advantage.

TABLE VI

Moisture absorption of ferro-alumino silicates at different humidities

Composition.		Humidities					
Sample No.		10%	50%	70%	90%	95%	100%
1. Iron silicates							
	a. unactivated	1.6	6.0	12.4	18.8	31.2	34.7
	b. activated	6.8	8.8	14.2	20.5	30.2	32.8
2. Fe silicate 80% + Al silicate 20%							
	a. unactivated	0.0	0.0	3.0	17.0	23.0	26.0
	b. activated	8.2	10.2	18.02	26.4	30.8	40.0
3. Fe silicate 50% + Al silicate 50%							
	a. unactivated	—	—	—	—	—	—
	b. activated	11.05	13.0	20.5	27.5	30.2	43.5
4. Fe silicate 40% + Al silicate 60%							
	a. unactivated	—	—	—	—	—	—
	b. activated	10.5	13.6	24.2	27.5	41.2	43.2
5. Fe silicate 20% Al silicate 80%							
	a. unactivated	0.8	8.8	13.0	21.9	32.6	32.0
	b. activated	12.5	17.4	27.0	88.0	49.5	44.0
6. Holmes silica prepared by dissolution of Fe_2O_3 activated.		6.6	38.2	39.8	44.0	65.8	72.2

In this table are also included the data obtained with Holmes silica prepared from ferric oxide-silica gel. It is seen that at 10% humidity, iron oxide-silica gel (sample No. 1) absorbs more moisture ; but at all higher humidities, the silica gel, obtained after dissolution of ferric oxide, absorbs more moisture. This is because, as a result of dissolution of iron oxide, more capillary space becomes available with simultaneous increase in the size of the capillaries.

The results given in Table VI further show that as the percentage of alumina increases, the moisture absorption goes on increasing at almost all humidities. This is probably due to the fact that alumina is a better absorbent than ferric oxide. This point was tested by comparing moisture absorption of ferric oxide and alumina samples prepared and activated in similar manner. For this purpose two samples of ferric oxide and alumina were precipitated from their chlorides and sulphates by the addition of ammonia. They were subsequently washed, dried and then activated. The results of moisture absorption are given in Table VII. It it is seen that Al_2O_3 is a better absorbent at all humidities.

TABLE VII.

Comparison of moisture absorption capacity
of Fe (OH)$_3$ *and* Al (OH)$_3$, *both activated.*

		Moisture absorbed (%) from atmosphere of different humidities.					
		10%	50%	70%	90%	95%	99%
1.	*a.* Fe (OH)$_3$ obtained from Ferric sulphate	6.1	6.1	12.1	13.7	15.6	17.1
	b. Alumia obtained from Al$_2$ (SO$_4$)$_3$	7.1	14.05	16.1	28.9	53.5	62.0
2.	*a.* Fe(OH)$_3$ obtained from ferric chloride.	8.1	8.2	18 5	15.7	24.0	25.4
	b. Al (OH)$_3$ obtained from AlOl$_3$.	11.1	12.5	15.6	21.8	48.0	57.8

The results mentioned in the foregoing clearly show that all the three main constituents of soils, namely Al_2O_3, Fe_2O_3 and SiO_2, are good absorbent on account of their cellular nature and this leaves no doubt that moisture absorption and its retention in soils is due, in a large measure, to the presence of these substances. The mechanism of moisture absorption appears to be that it is held up in the capillary spaces between the individual molecules or aggregates of Fe_2O_3, Al_2O_3 and SiO_2. The partial elimination of the sesquioxides from soils on treatment with acids, results in widening the capillary spaces, making the material good adsorbent for the purpose of bleaching crude vegetable oils and other allied purposes, but at the same time decreasing its moisture-absorption capacity from the vapour phase.

Bleaching of Vegetable Oils by Silica Samples.

It was thought of interest to study the bleaching properties of various silica samples towards crude vegetable oils. Crude cotton seed oil was selected for this purpose. The method employed was the same as used by Sarin and Kukeraja (*J. Indian Chem. Soc. Ind. & News Ed.*, 1941, 4, 184) and consisted in mixing 0.5. g. of silica with 10 c.c of the crude oil and heating the mixture at 90° for 10 minutes with constant stirring. The oil was then filtered and the extent of bleaching determined by means of the Duboscq colorimeter taking the unbleached oil as the standard. The results are given in Table VIII.

TABLE VIII

Bleaching of oils by different activated silica samples.

No.	Description of sample.	Bleaching values : Liquid depths giving the same colour as 10 depths of original oil values for	
		activated samples.	unactivated samples.
A.	Silica sample obtained by method of Bartel and Fue.	13.7	12.55
B.	Patrick gel.	13.6	11.8
C.	Holmes sillica obtained by mixing		
	1. CrCl$_3$+sod. silicate solution.	12.0	11.6
	2. Ni chloride+sod. silicate solution	14.00	12.55
	3. Co chloride + sod. silicate solution.	13.00	12.9
	4. Ferric chloride + sod. silicate solution.	15.5	14.0
D	Silica obtained by boiling fused sodium silicate with sulphuric acid.	11.43	
F.	Bleachede.	17.2	
G.	Tonsil	15.6	

Similar results obtained with bleachede and tonsil, two commercial bleaching materials used for this purpose, are also included in the table. It is seen that activated samples of silica are fairly good adsorbents for colouring matters and that the sample prepared from ferric oxide-silica gel (No. C. 4) gives the best results.

Effect of Time of Activation on Moisture Absorption capacity of Silica Samples.

On perusal of literature it is found that usually two hours of activation is recommended. During this time it is presumed that the maximum drying of the capillaries has taken place. The effect of temperature at which activation is done has been studied in details by Holmes and Elder (loc. cit.) who found that heating to a temperature anywhere between 100° and 800° does not affect the quality of the sample. Heating beyond 800°, however, was found to decrease the activity appreciably. Usually activation is done therefore at 200°. The effect of time of activation has not been studied in details so far. It was therefore thought of interest to activate the sample for different lengths of time and to study any change produced in the activity of the sample. Results of these experiments are given in Table IX. It is seen that moisture absorption capacity of the sample at all humidities goes on increasing with increase in the time of activation up to three hours. If activation is continued for a longer time, it seems that while little or no change is produced as far as moisture absorption from atmospheres of higher humidities are concerned, there is a fall in the values obtained from atmospheres of lower humidities (up to 50%).

TABLE IX

Moisture absorption capacity as affected by the time of activation.

Time.	10%	50%	70%	90%	96%	99%
1 hr.	7.0	8.8	16.3	34.1	63.4	70.1
2 „	14.0	14 5	19.6	36.0	73.4	74 2
3	16.4	18.4	22.4	38.8	70.0	75.8
5	12.3	12.6	23.5	39.0	68.0	74.6
7	12.5	13.3	23.5	39.2	68 5	75 2
9	11.2	11.8	21.8	36.8	69.7	75.8

It appears therefore that the period of activation should not exceed 3 hours. During this time most of the water present in the unactivated sample is removed. The rest of the water seems to be held much more firmly, apparently in such fine capillaries that when this water is sought to be removed either by increasing the time of activation, or by raising the temperature, the gel structure appears to partially collapse, decreasing its moisture absorption capacity.

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A STUDY OF ASCORBIC ACID SYNTHESIS BY ANIMALS *IN VIVO*

By Baidyanath Ghosh

An intraperitoneal injection of sodium pyruvate was found to induce an increased formation of ascorbic acid *in vivo* in chloretone-fed and ether-anaesthetized rats. Guineapigs and rabbits on the contrary are unable to synthesise ascorbic acid under similar experimental conditions.

Recently Smythe and King (*J. Biol. Chem.*, 1942, **142**, 529) have described *in vitro* synthesis of ascorbic acid by the tissues of choretone-fed rats. The tissue slices from chloretone-treated rats were suspended in Ringer-bicarbonate solution in a Warburg manometer and the transformation was effected anaerobically in an atmosphere of 5% CO_2 and 95% N_2. The liver and kidney tissues of the chloretone-fed rats showed greatest evidence of ascorbic acid synthesis when a mixture of pyruvate, *dl*-glyceryl aldehyde and hexose diphosphate was employed as a substrate in the above experiment.

The above transformation was neither possible in presence of air (oxygen) nor by the tissues of normal (untreated) rats.

Thus the experimental observation of Smythe and King (*loc. cit.*) showed the possibility of ascorbic acid formation by narcotized tissues by the interaction of normal breakdown products of carbohydrate metabolism. No explanation of the mechanism of the above transformation has been put forward. In the present investigation experiments have been described to find if any simple carbohydrate moiety, especially glucose, lactate and pyruvate, can induce increased formation of ascorbic acid *in vivo* in intact rats under similar narcotized conditions.

A quick method for the determination of ascorbic acid formed in the urine of intact animals has been adopted analogous to that described by Smith and Orten (*J. Biol. Chem.*, 1939, **128**, 101) for the determination of the rate of citric acid formation.

The discharge of urine from the bladder of the experimental animal was prevented by closure of the external orifice with a ligature and the ascorbic acid content of the accumulated urine was estimated titrimetrically. The ascorbic acid contents of the liver and kidney tissues of the experimental animals were also determined. Guineapigs and rabbits were likewise treated for comparative study.

EXPERIMENTAL

Normal rats.—Male rats of about 200 g. in weight were selected for the present investigation. These rats were bred in this laboratory and were kept on normal diet of whole wheat, brown bread, milk and water *at libitum*.

Chloretone-fed rats.—Each of the selected rats was fed with 20 mg. of chloretone, dissolved in 0.1 c.c. of coconut oil for a period of four days. On the fourth day after feeding chloretone, the chloretone-fed rat was treated as described under experimental procedure.

Ether-anaesthetized rats.—Ether produced an increase in the concentration of ascorbic acid in the blood and tissues of rats (Ghosh, *Ann. Biochem. Expt. Med.* 1943, **3**, 15). Normal rats after being injected intraperitoneally with test solution were allowed to inhale ether (soaked in cotton wool) inside an inverted glass funnel (12-14″ diam.). Ether was poured in at intervals continuously for 2 hours and after that period the animals were suffocated to death by excessive inhalation of ether.

Guineapigs.—Male guineapigs weighing between 250 and 300 g. were selected. Experimental period was 2 hours. An intraperitoneal injection of 10 c.c. (200 mg.) of test solution was administered. Guineapigs were similarly fed for 4 consecutive days with 50 mg. of chloretone dissolved in 0.2 c.c. of coconut oil.

Rabbits.—Male rabbits weighing between 1 kg. and 1.5 kg. were similarly fed for 4 consecutive days with 1.0 c.c. of coconut oil containing 200 mg. of chloretone. 30 C c. of saline were injected and the experimental period was for three hours.

Procedure.—Before intraperitoneal injections of the test solution were given, the external urethral orifice of each experimental animal was closed by a ligature (twine cord was found quite suitable) so that the discharge of urine from the bladder was not possible. The experimental period for rats and guineapigs was 2 hours while for rabbits it was 3 hours. At the end of the experimental period (i.e. 2 hours in case of rats) each animal was killed by a blow (except in case of ether anaesthesia). The animal was then fixed on a paraffin tray and a mid-line incision was made and the urinary bladder was isolated. The ureter and urethra were closed by a ligature and the bladder full of urine was carefully removed. The ligatured bladder was very cautiously washed with distilled water by gentle blowing of water from a wash-bottle. The urine inside the badder was quantitatively collected into a small beaker (50 c.c.) containing 1 c.c. of glacial acetic acid, which was used to prevent ascorbic acid oxidation. The inside of the bladder was washed thoroughly for 3-4 times ; the washings were collected along with the acidified urine and the total collection was made up to a definite volume (25 c.c.). The ascorbic acid content of the urine was determined by titration against standard 2 : 6-dichlorophenol-indophenol solution.

The ascorbic acid contents of the liver and the kidney tissues of the experimental animals were also determined titrimetrically.

Test solutions.—A sterile physiological saline (0.9% sodium chloride autoclaved for ¼ hour under 15 lbs. pressure) solution was employed throughout the experiment.

Pyruvate, lactate and glucose (100 mg. each) were dissolved separately in 5 c.c. of the above sterile solution and were injected intraperitoneally in the experimental rats.

Results of intraperitoneal injection of saline, glucose, lactate and pyruvate into intact rats under normal, chloretonized and etherized conditions are given below in Table I. The results are based on the average of 6 separate sets of experiments. Figures are given in mg. of ascorbic acid formed in the urine which was collected from the bladder of experimental rats.

TABLE I

Mg. of ascorbic acid present in the total quantity of urine collected during 2 hours of experiment.

No.	Experimental condition of rats	Test	solutions	injected	(5 c.c).
		Saline.	Glucosee (100 mg.).	Lactate (100 mg.).	Pyruvate (100 mg.).
1.	Normal (controls)	0.168	0.169	0 135	0.185
2.	Chloretone-fed	0.299	0.312	0.282	0.410
3.	Ether-anaesthetized	0.154	0.171	0.205	0.282

It is evident that chloretone is effective in inducing an increased formation of ascorbic acid in the rat. A further accelerating effect may be noticed, if pyruvate was injected intraperitoneally in the chloretone-fed rats. Pyruvate was also found to be effective in increasing the formation of ascorbic acid 'in intact rats under ether anaesthesia. Therefore, an inference may be drawn that the pyruvate is a major metabolite which accumulates and simultaneously undergoes transformation into ascorbic acid under the action of both chloretone and ether. Accumulation of pyruvic acid and the mechanism of its transformation into ascorbic acid still remains to be proved 'experimentally. However, the present observation indicates that pyruvic acid takes a leading role in the above transformation.

The ascorbic acid content of the liver and kidney tissues of the normal, chloretone-fed and etherised rats under various experimental conditions are given in Table II.

TABLE II

Mg. of ascorbic acid per g. of (moist) tissue. Experimental period was 2 hours. Number of rats for each set of experiment was 6.

No.	Expt. condition	(a) Liver				Saline.	Test solution injected (b) Kidney		
		Saline	Glucose	Lactate	Pyruvate		Glucose.	Lactate.	Pyruvate.
						0.164	0.160	0.127	0.110
1.	Normal rates	0.185	0.162	0.118	0.166	0.251	0.186	0.138	0.158
2.	Chloretone-fed rats	0.279	0.217	0.191	0.226	0.231	0.256	0.220	0.226
3.	Etherised rats	0.217	0.242	0.260	0.282				

From Table II it will be observed that the ascorbic acid concentration in the liver and kidney tissues was greater in choretone-treated and ether-anaesthetized rats than those of untreated rats under identical experimental conditions. The total amount of ascorbic acid in these organs, however, was found to have decreased when injected with sodium pyruvate and sodium lactate. This decrease in the ascorbic acid content is probably due to introduction of an excess concentration of sodium ion.

The output of ascorbic acid in the urine of guineapigs under the conditions of normal, chloretone-fed, ether-anaesthesia and anoxia are given in Table III for the sake of comparative study. 200 Mg. of pyruvate in 10 c.c. of saline were injected

into normal and chloretone-fed guineapigs.   Only very slight increase in the ascorbic acid content in the urine of chloretone-fed guineapigs was observed.   No marked effect of pyruvate was, however, observed in the case of chloretone-fed guinespigs. It is therefore clear that ascorbic acid synthesis is not possible by guineapigs under narcotized condition.

TABLE III

Mg. of ascorbic acid present in the urine of guineapigs under experimental conditions noted.
(a)   10 c.c. of saline injected.

A	Normal	Chloredone-fed	Ether anaesthetized	Anoxia
	0.076	0.093	0.059	0.036

(b)   10 c.c. of pyruvate (100 mg. in saline) solution.

B	Normal	Chloretone-fed
	0.062	0.072

Similar treatment with chloretone and saline injection produced no increased elimination of ascorbic acid in the urine of rabbits (Table IV).

TABLE IV

Each rabbit was fed with 200 mg. of chloretone for a period of 4 days.
100 c.c. of saline were injected intraperitoneally.   Experimental period was 2 hours.

Mg. of ascorbic acid collected from the bladder.

No.	Normal rabbit.	Chloretone-fed rabbit.
1.	0.433	0.325
2.	0.274	0.260
	Mean 0.353	0.292

CONCLUSION

Rats can excrete an increased quantity of ascorbic acid when fed with chloretone.   Still more marked increase in the ascorbic acid content of the urine of chloretone-fed rats and of the urine of ether-anaesthetized rats was observed when injected with 100 mg. of pyruvate intraperitoneally.   It seems likely that the pyruvate (pyruvic acid) may be an important metabolite or precursor which is concerned in ascorbic acid synthesis by the rat under narcotized condition.

The ascorbic acid content of the tissues like liver and kidney of the rat was found to be higher under narcotized condition.   It is likely that all the organs and tissues of the rat under the action of narcotics take part in the synthesis of ascorbic acid.   Similar views have been expressed by Sutton, Kaeser and Hansard (*J. Biol. Chem.*, 1942, **144**, 183).   It would thus appear that no particular tissue or organ of the rat is responsible for ascorbic acid synthesis.

Guineapigs and rabbits are unable to synthesise ascorbic acid under similar narcotized conditions.

In conclusion, my best thanks are due to Prof. B. C. Guha for his interest and giving me full facilities to carry out this investigation.

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STUDIES IN INDIGOID DYES. PART V. (METHYL)THIONAPH-THENE-PHENANTHRENE-INDIGOS

By Sisir Kumar Guha

Phenanthraquinone and its 2-nitro derivative have been condensed with 4-, 5-, 6-, and 7-methyl-3-hydroxythionaphthene respectively. The isomeric (methyl)thionaphthene-phenanthrene-indigos are chocolate and violet dyestuffs. The changes in colour due to the substitution of a methyl group in 4, 5, 6, and 7 positions of the thionaphthene nucleus of some of these dyestuffs were found out by location of their absorption maxima in the microphotograms. It is revealed that they are of the same order as those of the isomeric indole-(methyl) thionaphthene-indigos, (methyl) thionaphthene-aceanthrylene-indigos, dimethylthioindigos and bis-(methyl)thionaphthene-ethylene-indigospreviously studied by the author.

It has been established recently by the author that in the case of asymmetrical thioindigoid vat dyes, the isomeric indole-(methyl)thionaphthene-indigos, and methyl (thionaphthene)-aceanthrylene-indigos, and also in the case of symmetrical dyes, the isomeric dimethylthioindigos and the bis(methyl)thionaphthene-ethylene-indigos, the change in their colours may be arranged in the order : 5-methyl dye⟩ 4-methyl dye⟩ 6-methyl dye⟩ 7-methyl dye, and the position of colour of the parent dye of each of the series mentioned above is next to that of its 5-methyl substituted dye (Guha, J. Indian Chem. Soc., 1944, 21, 87, 391).

As a further test of this general observation, the author has studied in the present paper the influence of a methyl group when it is present in all the theoretically possible different positions of the thionaphthene ring of the 2-thionaphthene-9'-phenanthrene-indigo and its 2'-nitro derivative only (Friedländer, Herzog and Voss, Ber., 1922, 55, 1591 ; Pummerer and Luther, ibid., 1931, 64, 831 ; Dutt, J Indian Chem. Soc., 1932, 9, 99), which are also good instances of asymmetrical dyes belonging to phenanthraquinone series.

With this object in view, 4-, 5-, 6-, and 7-methyl-3-hydroxythionaphthenes (E.P., 279489/27 ; Guha, J Indian Chem. Soc., 1938, 15, 23 ; Auwers and Arndt, Ber., 1909, 42, 541; Friedländer, Ber., 1876. 9, 589 : Auwers and Thies, Ber., 1920, 53, 2293 ; Guha, J. Indian Chem. Soc. 1943, 20, 37) were condensed with phenanthraquinone, and its 2-nitro derivative only. The vat dyes prepared now are : 2-(4-methyl)-, 2-(6-methyl)-, and 2-(7-methyl)-thionaphthene-9'-phenanthrene-indigo ; 2-(4-methyl)-, 2-(5-methyl)-, 2-(6-methyl)-, and 2 (7-methyl)-thionaphthene-9'-(2'-nitro)-phenanthrene-indigo. The 2-(5-methyl)thionaphthene-9'-phenanthrene-indigo was described before by Guha and Basu-Mallick (J. Indian Chem. Soc., 1934, 11, 395).

These dyes are chocolate and violet coloured substances, generally soluble in high boiling solvents, such as pyridine, xylene, nitrobenzene and aniline. They dissolve in concentrated sulphuric acid producing a characteristic colouration. They generally melt at a high temperature, above which, when strongly heated, they volatilise. Their dyeing shades on wool from an acid bath are uniformly and fully developed.

But the shades on cloth from the hydrosulphite vat, in which the dyes dissolve with a yellow colour, are light and at the same time unsatisfactory, although the dyes themselves are deep (*cf.* the isomeric naphthathiophene-9'-phenanthrene-indigos, Dutt, *Ber.*, 1934, **67**, 5, 1319).

On comparing the colours of these isomeric (methyl)thionaphthene-phenan-threne-indigos and their dyeing shades, it is found that their change in colour is also of the same order as those of the asymmetrical dyes of isatin and aceanthrenequi-none series, and the symmetrical vat-dyes of thioindigo and *bis*thionaphthene-ethylene-indigo series (*loc. cit.*). For the quantitative measurement of the absorption maxima of these dyes and to substantiate the qualitative views, the absorption spectra of some of the dyes have been measured in nitrobenzene solution For this purpose, the isomeric (methyl)thionaphthene-(nitro)-phenanthrene-indigos are chosen, as it is found easy to make a sharp distinction between their colours. The absorp-tion curves (Figs. 1 & 2) drawn by a microphotometer and also the absorption maxima (Table I) found out by calculation from a graph readily confirm what is deduced by the qualitative examination.

TABLE I

Me = Methyl ; T = Thionaphthene ; P = Phenanthrene-indigo.

Compounds.	Absorption maxima
2-(4-Me)-T-9'(2'-nitro)-P	5515 A.U.
2-(5-Me)-T-9'(2'-nitro)-P	5585
2-(6-Me)-T-9'(2'-nitro)-P	5495
2-(7-Me)-T-9'(2'-nitro)-P	5475

It did not seem worth while to attempt to prepare more of (methyl)thio-naphthene-phenanthrene-indigos having different types of substituents in the phenan-threne part of the dye molecule, as it is observed that the dyes of this class generally impart to cloth lighter shades of their real colour which stand greatly in their way of fulfilling the chief object of utilising them as vat colours [the isome-ric indole-(methyl) thionaphthene-indigos and (methyl)-thionaphthene-acenaphthylene-indigos whose beautiful shades have been rapidly developed on cotton as well as on wool, Guha, *loc. cit.* ; Guha, *J. Indian Chem. Soc.*, 1943, **20**, 37 ; 1944, **21**, 91).

E X P E R I M E N T A L

2-(4-Methyl)-thionaphthene-9'-phenanthrene-indigo separated as a dark chocolate (almost black) crystalline precipitate when phenanthraquinone (1.04 g.) and 4-methyl-3-hydroxythionaphthene (0.829 g.) in 47 c.c. of glacial acetic acid and 2 c.c. of concentrated hydrochloric acid were boiled for 15-20 minutes in an atmos-

FIG. 1.
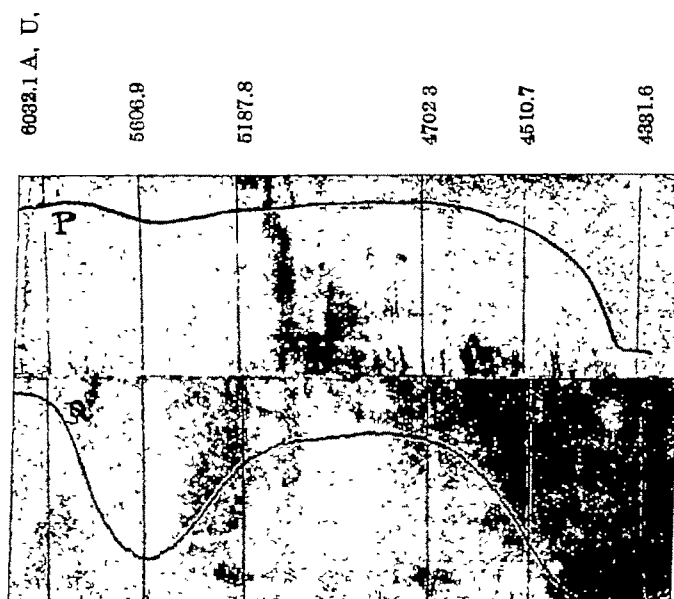
Curves P and Q refer respectively to 2-(4-methyl)-and 2-(5-methyl)-
-thionaphthene-9'-(2'-nitro)-phenanthrene-indigo.

FIG. 2,
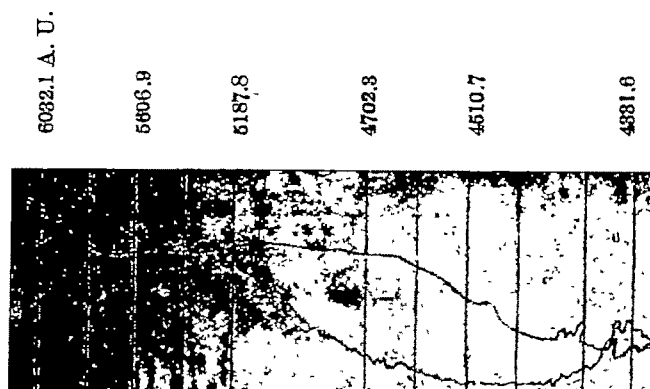
Curves R and S refer respectively to 2–(6-methyl) and 2–(7-
methyl) thionaphthene – 9' – (2' – nitro)-phenanthrene-indigo.

phere of carbon dioxide. The dye (0.584 g.) was purified by dissolving in a mixture of pyridine and nitrobenzene and precipitated by water, washed with dilute alcohol and hot water. It melts above 295°. It is moderately soluble in alcohol, acetic acid and benzene. It dissolves in cold concentrated sulphuric acid to a faint greenish brown colour. It dyes wool and cloth in blackish brown shade. (Found : S, 9.39. $C_{23}H_{14}O_2S$ requires S, 9.04 per cent).

2(6-*Methyl*)*thionaphthene-9'-phenanthrene-indigo* was similarly obtained from phenanthraquinone (0.624 g.) and 6-methyl-3-hydroxythionaphthene (0.492g.) in 45 c.c. of glacial acetic acid and 4 c.c. of concentrated hydrochloric acid. The dark chocolate crystalline substance (0.396 g.) was purified at first by boiling with alcohol in which it is sparingly soluble and then precipitating from pyridine solution by the addition of water. It melts above 310°. It is moderately soluble in chloroform, acetic acid and benzene ; sparingly soluble in acetone. The solution of the substance in cold concentrated sulphuric acid is black-brown. It dyes both wool and cloth in the same shade as the preceding compound. (Found : S, 9.45. $C_{23}H_{14}O_2S$ requires S, 9.04 per cent).

2-(7-*Methyl*)*thionaphthene-9'-phenanthrene-indigo.*—Phenanthraquinone (0.416 g.) and 7-methyl-3-hydroxythionaphthene (0.328 g.) were dissolved in 25 c.c. of boiling glacial acetic acid and concentrated hydrochloric acid (3 c. c.) added when at once a lump of the dye separated ; more of glacial acetic acid (20 c. c.) was added and boiled for 20 minutes. The crystalline light chocolate precipitate (0.33 g.) was purified similarly as the preceding compound melting above 300°. It is soluble in chloroform, sparingly soluble in glacial acetic acid and benzene. It dissolves in concentrated sulphuric acid in cold producing a reddish brown colour. It imparts light brown shade to wool and blackish brown shade to cloth. (Found : S, 9.41. $C_{23}H_{14}O_2S$ requires S, 9.04 per cent.).

2-(4-*Methyl*)*thionaphthene-9'-(2'-nitro)-phenanthrene-indigo* separated as a violet crystalline precipitate on treating a boiling solution of 2-nitrophenanthraquinone (0.759 g.) and 4-methyl-3-hydroxythionaphthene (0.492 g.) in glacial acetic acid (95 c.c.) with concentrated hydrocloric acid (5c.c.) and heating for 15-20 minutes. The dye (0.224 g.) was obtained from xylene in star-shaped crystals melting at 302° (decomp.). It is soluble in benzene, sparingly soluble in alcohol. Cold concentrated sulphuric acid dissolves it producing a deep green solution. It dyes wool in dark violet shade from an acid bath and cotton in faint violet shade from the hydrosulphite vat. (Found : N, 3. 74. $C_{23}H_{13}O_4NS$ requires N, 3.51 per cent).

2-(5-*Methyl*)*thionaphthene-9'-(2'-nitro)-phenanthrene-indigo* was similarly prepared as the 4-methyl dye from 2-nitrophenanthraquinone (1.012 g.) and 5-methyl-3-hydroxythionaphthene (0. 656 g.) in 122 c.c. of boiling glacial acetic acid and concentrated hydrochloric acid (5 c.c.). The violet small needle-shaped precipitate (0.898 g.) was crystallised from xylene in beautiful foliated needles melting at 280° (decomp.). It is slightly soluble in acetic acid and chloroform. The colour of the solution of the substance in cold concentrated sulphuric acid is leaf-green. It dyes both wool and cotton in the same shade as the preceding compound. (Found : N, 3.84. $C_{23}H_{13}O_4NS$ requires N, 3.51 per cent).

2-(6-Methyl)thionaphthene-9'-(2'-nitro)-phenanthrene-indigo was obtained as before from 2-nitrophenanthraquinone (1.012 g.) and 6-methyl-3-hydroxythionaphthene (0.656 g) in 120 c.c. of boiling glacial acetic acid and 6-7 c.c. of concentrated hydrochloric acid in violet coloured crystalline precipitate (1.118g.). It was crystallised from nitrobenzene in fine small needles melting above 300° (with previous shrinking at 295°). It is moderately soluble in amyl alcohol and acetic acid sparingly soluble in alcohol. Cold concentrated sulphuric acid dissolves it producing the same colour as the 5-methyl dye. It dyes wool violet from an acid bath and cloth in light violet shade from the hydrosulphite vat. (Found: N, 3.55. $C_{23}H_{13}O_4NS$ requires N, 3.51 per cent).

2-(7-Methyl)thionaphthene-9'-(2'-nitro)-phenanthrene-indigo.—2-Nitrophenanthraquinone (0.759 g.) was dissolved in a little more than the required quantity of boiling glacial acetic acid and to this solution 7-methyl-3-hydroxythionaphthene (0.492g) was added and the solution shaken well. The resulting red-brown solution on treatment with concentrated hydrochloric acid (3-4 c.c.) and boiling in an atmosphere of carbon dioxide for about 20 minutes, gave a crystalline violet coloured substance (1 g.). It was crystallised from a mixture of nitrobenzene and xylene in dark violet dye (almost black) melting above 300°. It is sparingly soluble in acetic acid, benzene ; insoluble in alcohol. Concentrated sulphuric acid dissolves it with a light yellowish green colour. It dyes wool in light violet-brown shade and cloth in blackish brown colour. (Found : N, 3.41. $C_{23}H_{13}O_4NS$ requires N, 3.51 per cent).

STUDIES OF CARBONYL COMPOUNDS. PART I. THE FORMATION OF THE SODIUM DERIVATES OF SUBSTITUTED MALON AND METHYLMALON AMIDES

By M. L. Shah

Carbonyl compounds such as the disubstituted amides of malonic and methylmalonic esters have been heated with molecular sodium, and it is found that monosodium derivatives are obtained.

With a view to studying the reactivity of the hydrogens of the reactive methylene (-CH₂-) group Naik and Shah (*J. Indian Chem. Soc.*, 1931, 8, 45) took up the study of sodium compounds of the substituted amides of cyanoacetic ester and prepared monosodium compounds of the general formula, $CN.CHNa.COR$, where $R = OEt$, NH_2, $NHMe$, etc. Similar monosodium derivatives of the disubstituted amides of malonic and methylmalonic esters have been prepared by the author under similar experimental conditions. The main results of the work may be summarised thus :

Type I. Conversion of $H_2C(CO.NH.R)_2$ into $HNaC(CO.NH.R)_2$ where $R =$ phenyl, *o*-tolyl, *m*-tolyl, *p*-tolyl, ∝-naphthyl, β-naphthyl, 1 : 4 : 5-xylyl or benzyl group.

Type II. Conversion of $HCH_3C (CONH.R)_2$ into $NaCH_3C (CO.NH.R)_2$ where $R = p$-tolyl or *o*-tolyl.

Malonamide, malon monophenylamide and malon-mono-*o*-tolylamide are found to remain unreacted under the experimental conditions.

EXPERIMENTAL

Mononsodio-malon-di-phenylamide, was obtained by adding malon-diphenyl-amide (2.5 g.) to molecular sodium (0.5 g.) in presence of about 30 c.c. of dry benzene, and heating under reflux for 6 hours, at the end of which the excess of sodium melted and stuck at the bottom of the flask. The sodium compound separated out from benzene. The white amorphous mass was filtered and washed with light petroleum. It was then dried in a desiccator over anhydrous calcium chloride and phosphorus pentoxide. It slowly turns yellow above 60°, turns red and shrinks above 203°, slowly decomposes and chars above 210°, and does not melt even at 270°. The other sodio compounds are listed in Table I.

It is practically insoluble in benzene, toluene, ether and light petroleum. (Found : N, 10.42 ; Na, 8.04. $C_{15}H_{13}O_2N_2Na$ requires N, 10.14 ; Na, 8.33 per cent).

TABLE I

	M. p.	Formula	Analysis. Found.	Calc.
Monosodio-malon-di-p-tolylamide	Turns yellow and shrinks above 180°; turns reddish above 200°, decomposes and chars above 252°.	$C_{17}H_{17}O_2N_3$ N_a	Na 730	7.56
Monosodio-malon-di-m-tolylamide	Turns yellow and shrinks above 145°, turns red above 220°, decomposes and chars above 245°	$C_{1?}H_{1?}O_2N_2$ Na	7.40	7.56
Mononsodio-malon-di-o-tolylamide	Shrinks above 90°, turns yellow above 180°, m.p. 200° (decomp.)	$C_{17}H_{17}O_2N_2$ Na	7.35	7.56
Monosodio-malon-di-α-naphthylamide	Shrinks above 155°, m.p. 173°	$C_{24}H_{1?}O_2N_2$ Na	5.79	6.12
Monosodio-malon-di-β-naphthylamide	Shrinks above 200°, m.p. 215° (decomp.)	,,	5.77	6.12
Monosodio-malon-di-1:4:5-xylidide	Shrinks above 215°, m.p, 228° (decomp.)	$C_{10}H_{21}O_2N_2$ Na	6.84	6.93
Monosodio-malon-di-n-propylamide	Shrinks above 125°, turns yellow above 180°, turns reddish yellow above 225° not melting at 270°	$C_9H_{17}O_2N_2$ Na	11.12	11.05
Monosodio-malon-di-benzylamide	Shrinks above 155°, decomposes and chars at a higher temp.	$C_{17}H_{17}O_2N_2$ Na	7.20	7.56
Monosodio-methylmalon-di-p-tolylamide	Shrinks above 120°, turns yellow above 150°, reddish above 182°, decomposes and chars above 265°	$C_{18}H_{19}O_2N_2$ Na	6.89	7.33
Monosodio-methylmalon-di-o-tolylamide	Shrinks and turns yellow above 175°, m.p. 182° (decomp.)	$C_{18}H_{19}O_2N_2$ Na	7.14	7.23

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A NOTE ON THE PROPERTIES OF SODIUM HYPONITRITE

By C. C. Shah

Oza (*J. Indian Chem. Soc.*, 1945, **22**, 225) has reported the properties and preparation of sodium hyponitrite and showed the existence of a tri-hydrate. The present author has investigated in great detail the properties of hyponitrites (Partington and Shah, *J. Chem. Soc.*, 1931, 2071 ; 1932, 2589). There is nothing new in the properties described by Oza. The hydrated salt has not even been analysed, both in his previous paper (*J. Indian Chem. Soc.* 1944, **21**, 70) and in the present paper. The present paper only gives the loss in weight. Probably it is assumed that the loss is due to water, inspite of the author's statement on page 77 of the first paper.

The present author has prepared large quantites of hyponitrites and he feels that it is not necessary to bubble nitrogen during reduction. The gases evolved in the flask protect the liquid from atmospheric CO_2. As mentioned however by him, nitrogen should be passed during the filtration of the product.

Oza has analysed $Na_2N_2O_2$ by a volumetric method which is unpublished. The author feels that it is not possible to *accurately* determine hyponitrite by any volumetric method due to the great instability of its solution inspite of Oza's observation on the effect of CO_2 on it.

As regards the action of potassium iodide, the author would refer to page 2072 of his first paper. I do not think Oza has any thing more to add.

Oza in his first paper has studied the thermal decomposition giving the furnace temperature for the decomposition temperature of the salt. The furnace temperature is bound to be higher. He complains that the author did not give any analytical results. They can be found on page 2077 of the first paper. Oza mentions the presence of nitric oxide in the gaseous product but does not mention it in the analysis.

Oza has not given any more information on the properties of hyponitrites than those contained in our papers.

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STUDIES IN THE NEGATIVELY CHARGED COLLOIDAL SOLUTIONS OF VARIOUS FERRIC SALTS. PART I. NEGATIVELY CHARGED MIXED SOL OF FERRIC OXIDE AND FERRIC VANADATE

BY S. P. MUSHRAN AND SATYA PRAKASH

The negatively charged ferric vanadate sols have been prepared and studied for the first time. The paper describes the composition and various other properties of the sols. The glucose-peptised sol has the composition $19Fe_2O_3 . 2Fe(VO_3)_3 . H_2O$ and the glycerine-peptised sol $7Fe_2O_3 . Fe(VO_3)_3 . H_2O$.

In some of the previous publications, Prakash and Dhar (*J. Indian Chem. Soc.*, 1929, **6**, 587, 391 ; 1930, **7**, 367) have referred to their work on ferric molybdate and tungstate jellies. No work seems to have been done on ferric vanadate sols.

It is long known that the addition of mineral acid to a concentrated solution of an alkali or alkaline earth vanadate throws down vanadium pentoxide to a red-brown amorphous hydrous mass, very much similar to hydrous ferric oxide. Biltz (*Ber.*, 1904, **37**, 1098) treated ammonium vanadate with a dilute solution of hydrochloric acid and obtained vanadium pentoxide as a brownish powder which on thorough washing peptised completely in water giving a clear reddish yellow sol. The optical properties of this sol were studied by Freundlich and co-workers (*Koll.-Chem. Beih.*, 1915, **7**, 207 ; *Phys. Z.*, 1915, **16**, 422 ; *Z. Elektrochem.*, 1916, **22**, 27) ; the nature of the particles was studied by Zocher (*Z. physikal. Chem.*, 1921, **98**, 293 ; 1923, **105**, 119) ; and Dhar and collaborators (*J. Indian. Chem. Soc.*, 1932, **9**, 441 ; *J. Phys. Chem.*, 1929, **33**, 1905) studied in details the stability and various other characteristics of dilute as well as concentrated vanadium pentoxide sols and the condition of jelly formation. Though vanadium pentoxide sol has been studied in details, not much attention has been paid to the study of metallic vanadate sols.

In a recent communication, Mushran (*Current Sci.*, 1945, **14**, 233) has observed that in presence of glucose, ferric chloride dissolves a considerable amount of ammonium vanadate to give a red coloured sol of ferric vanadate which bears a positive charge. In another communication Mushran (*Current Sci.*, 1945, **14**, 123) has shown that if, however, ammonium vanadate is in excess, a permanent precipitate of ferric vanadate is obtained which can be dispersed by caustic soda to give a clear deep red sol of ferric vanadate which bears a negative charge. The peptisation is greatly facilitated by the addition of glucose or glycerine. In this paper we have undertaken the detailed study of the properties and composition of the sol.

EXPERIMENTAL

Sol (A) was prepared by mixing 50 c.c. of ferric chloride (corresponding to 30.36 g. of Fe_2O_3 per litre), 75 c.c. of ammonium vanadate (corresponding to 6.5485 g. of V_2O_5 per litre), 25 c.c. of a 20% glucose solution and 75 c.c. of an N-NaOH solution. The total volume was raised to 250 c.c. The sol was dialysed for six days.

Sol (B) was prepared by mixing 26 c.c. of ferric chloride (of the same strength), 40 o.c. of ammonium vanadate (of the same strength), 15 c.c. of glycerine and 40 c.c. of N-NaOH solution. The total volume was raised to 130 c.c. The sol was dialysed for two days.

Composition of Sols.

The amount of vanadium in the sol was estimated by dissolving the sol in Merck's hydrochloric acid and adding to this a known amount of standard ferrous ammonium sulphate solution. The excess of ferrous ammonium sulphate was titrated against a standard solution of potassium dichromate using potassium ferricyanide as an external indicator. The method is based on the fact that pentavalent vanadium is reduced quantitatively to the quadrivalent state by ferrous ammonium sulphate. The excess of ferrous ammonium sulphate gives a measure of vanadium pentoxide present. In these titrations, the iron is oxidised before the vanadium. The amount of iron in the sol was estimated by the method of Penny (*Dingl. Polyt. J.*, **149**, 490) by reducing ferric iron to the ferrous state by the addition of a freshly prepared stannous chloride solution the excess of which was removed by mercuric chloride and titrating iron against standard potassium dichromate solution. In order to find out how much of the vanadate is in the combined state with iron, a known volume of the sol was coagulated by potassium chloride. The coagulum was collected, thoroughly washed and estimated for vanadate. The coagula have also been obtained cataphoretically and the concordance of the results shows that the equilibrium between the free and combined vanadate is not appreciably altered during these processes. The combined iron corresponding to this amount of vanadate was calculated on the assumption that the ferric vanadate is $Fe(VO_3)_3$. The rest of the iron is present as hydrated ferric oxide. From the ratio of the free to the combined iron, the empirical formula of the sol can be suggested.

TABLE I

Per litre	Sol A. Glucose sol.	Sol B. Glycerine sol.
Total Iron	2.9505 g.	2.5686 g.
Total Vanadium (V_2O_5)	1.3741	1.0914
Combined Vanadium (V_2O_5)	0.7276	0.8167
Free Vanadium (V_2O_5)	0.6465	0.2747
Combined Iron	0.1488	0.1669
Free Iron	2.8107	2.4017
Viscosity of sol	0.00825	0.00839
Viscosity of water	0.00803	0.00803
Water, bound	0.01895	0.07898
Empirical formula	$19Fe_2O_3.2Fe(VO_3)_3.H_2O$	$7Fe_2O_3.Fe(VO_3)_3.H_2O$

The amount of bound water per litre of the sol was calculated from the Hatscheck's equation (*Kolloid Z.*, 1911, **8**, 34) expressed in the following form :

$$\text{Bound water per litre} = \frac{1000}{A} = 1000\left(\frac{\eta_s - \eta_w}{\eta_s}\right)^3$$

where A is the ratio of the total volume of water in the sol to the volume of water bound, η_w is the viscosity of water at 30° and η_s is the viscosity of the sol at the same temperature (*cf.* Prakash, *Kolloid Z.*, 1932, **60**, 184). The amount of water, thus computed, is not strictly the water molecularly combined; a part of it is associated with the micelles by the adsorptive forces.

The sols were coagulated cataphoretically and by $N/2$-KCl, centrifuged and the hydrogen ion concentration of the supernatant layers was determined by Hildebrand's hydrogen electrode. The following p_H values were recorded.

Glucose sol (A), 7.21 (KCl coagulated);

7.33 (cataphoretically coagulated).

Glycerine sol (B), 7.32 (KCl coagulated);

7.48 (cataphoretically coagulated).

Conductivities of Sols.

In the following tables, our observations on the conductivities of these sols at various temperatures, at various dilutions and also the values on ageing are recorded.

TABLE II

Conductivity values at dilutions (30°).

Dilutions	Conductivity		Date.	Conductivity	
	Glucose sol (A).	Glycerine sol (B).		Glucose sol (A).	Glycerine sol (B).
Original sol (X)	7.94×10^{-4} mhos.	14.23×10^{-4} mhos.	22.4.45	7.94×10^{-4} mhos.	—
5X/6	6.68	12.10	28.4.45	—	14.23×10^{-4} mhos.
2X/3	5.36	10.16	15.5.45	8.16	—
X/2	4.08	8.21	20.5.45	—	14.46
X/3	2.67	5.90	2.6.45	8.46	—
X/6	1.34	3.11	15.6.45	—	14.98
	—		2.7.45	8.88	16.52

Conductivity values at diff. temperatures.

Temp.	Glucose sol (A)		Glycerine sol (B)	
	Conductivity.	Diff. per 5°.	Conductivity.	Diff. per 5°.
40°	9.31×10^{-4} mho.		16.49×10^{-4} mhos.	
		0.69		1.15
35	8.62		15.34	
		0.68		1.11
30	7.94		14.23	
		0.70		1.20
25	7.24		13.03	
		0.69		1.13
20	6.55		11.90	
		0.68		1.18
15	5.87		10.72	
Temperature of zero conductance (extrapolated)			—23°	—28.5°.
Temperature coefficient per 1°			0.136	0.2312

A perusal of the above table shows that in the case of the glucose sol (A), the conductivities are approximately proportional to the dilutions, whilst in the case of the glycerine sol (B), the conductivities at various dilutions are always greater than those computed on the basis of dilution. Marked hydrolysis on dilution of sol (B) is thus indicated. The conductivities of both the sols increase with age. The increased values of conductivities with age indicate that either the adsorbed ions are released on account of loss of surface activity of the colloid particles or ferric vanadate is hydrolysed to give rise to such products which definitely contribute towards conductivity. The hydrolysis of the sols proceeds as follows :—

$$m\mathrm{Fe(VO_3)_3} + n\mathrm{H_2O} = (\mathrm{Fe_2O_3})_x + (m-2x)\ \mathrm{Fe(VO_3)_3} + 3x\mathrm{V_2O_5}.\ m\mathrm{H_2O}.$$
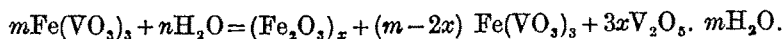
It was found by Kohlrausch that usually in case of electrolytes the temperature coefficients of conductivities amount to about 2% of the conductivities at 35°. But in case of sols and gels there are certain departures. Prakash (*J. Phys. Chem.*, 1933, **37**, 907) investigated the changes in conductivities of various sols and gels at various temperatures. The temperature coefficient of thorium arsenate jelly investigated by him varied irregularly from 0.9 to 1.4% of the conductance at 35°, whilst in the case of ferric arsenate gel it varied from 1 to 1.4% of the conductance at 35°. The temperature coefficients of conductivity per 1° and the conductances of negatively charged ferric vanadate sols at 35° investigated by us are given below.

	Condy. at 35°	Temp. coeff.
Glucose sol (A) ...	8.62×10^{-4}mhos	0.136
Glycerine sol (B) ...	15.34	0.2312

The temperature coefficient of sol (A) is thus 1.57% of the conductance at 35° and of sol (B) is 1.50% of the conductance at 35°.

Ordinarily it has been found that the conductance of electrolyte solutions becomes zero at temperatures near about 39°. Thorium jellies investigated by Prakash (*loc. cit.*) show that the temperatures of zero conductance range between —15° and 34°. The temperatures of zero conductance for ferric vanadate sols are :—

	Temp. of zero conductance.
Glucose sol (A)	—23°
Glycerine sol (B)	—28.5°

The temperature coefficients and temperatures of zero conductances of sols and gels are different from those of the true electrolytes for the obvious reason that as the temperature is raised, the colloidal micelles also are markedly affected. In some cases, on account of the change in surface energy, they liberate a few of the adsorbed ions which go to contribute towards the conductivities. In the case of the sols of the salts of heavy metals, hydrolysis also takes place to give rise to such products of hydrolysis which too affect electrical conductivities. This accounts for the deviation from Kohlrausch's rule.

Extinction Coefficients of the Sols.

Extinction coefficients were determined by Nutting's spectrophotometer at different dilutions and at different wave-lengths (X stands for the original undiluted sol).

Glucose sol (A)

Wave-lengths.		Dilution		
	X.	X/2.	X/4.	X/8.
5000 Å	...	4.16	2.08	1.03
5200	..	3.28	1.64	0.82
5400	...	2.28	1.14	0.57
5600	2.84	1.42	0.71	0.35
5800	1.94	0.97	0.49	0.24
6000	1.37	0.67	0.33	0.16
6200	1.02	0.52	0.26	0.13
6400	0.76	0.38	0.20	0.10
6600	0.57	0.28	0.14	0.07
6800	0.46	0.23	0.12	..

Glycerine sol (B)

5000 Å	4.28	2.46	1.55	0.85
5200	3.68	1.98	1.18	0.63
5400	2.85	1.55	0.82	0.42
5600	1.95	1.05	0.55	0.29
5800	1.35	0.72	0.39	0.24
6000	0.95	0.50	0.27	0.16
6200	0.70	0.37	0.22	0.13
6400	0.52	0.28	0.20	0.12

It will be seen from the above table that in the case of sol (A) Beer's law is almost rigidly followed, *i.e.*, the extinction coefficients are almost proportional to the dilutions. In the case of sol (B), the extinction coefficients are always more than those computed on the basis of dilution. The hydrolysis of ferric vanadate at different dilutions has caused deviations in the extinction coefficients—dilution relationship. Our results on the conductivities at different dilutions (Table II) also show similar behaviour.

Coagulation of the Sols.

In the following table are recorded the minimum amounts of electrolytes necessary to coagulate 1 c.c. of the sols in a total volume of 10 c.c., the time allowed in each case being 30 minutes.

TABLE IV

Electrolytes.	Glucose Sol (A) Amount necessary to coagulate	Glycerine sol (B) Amount necessary to coagulate
$N/2$ NaCl	4.6 c.c.	4.0 c.c.
$N/2$ KCl	2.8	2.8
$N/2$ KNO$_3$	2.8	2.8
$N/2$ KBr	2.8	2.8
$N/200$ Ba(NO$_3$)$_2$	2.7	2.6
$N/200$ Sr(NO$_3$)$_2$	4.0	3.0
$N/50$ AlCl$_3$	0.5	0.48

The coagulating power of the ions thus fall in the following series :—
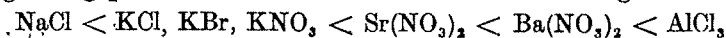
$$NaCl < KCl, KBr, KNO_3 < Sr(NO_3)_2 < Ba(NO_3)_2 < AlCl_3$$

The effect of dilution on the coagulation values has also been investigated. Total volume was 10 c.c.

TABLE V

Electrolytes.	Glucose sol (A)			Glycerine sol (B)		
	1 c.c. sol.	2 c.c. sol.	3 c.c. sol.	1 c.c. sol	2 c.c. sol.	3 c.c. sol.
$N/2$ NaCl	4.6	5.0	5.4	4.0	4.6	5.2
$N/2$ KCl	2.8	3.1	3.4	2.8	3.5	4.2
$N/2$ KNO$_3$	2.8	3.1	3.4	2.8	3.5	4.2

From Table V it is evident that the sols obey the ordinary Schulze-Hardy rule for the coagulation with electrolytes. They show the normal behaviour with dilution. The dilute sol requires lesser amount of electrolyte to coagulate it in a specified time.

CONCLUSIONS

1. The negatively charged sols of ferric vanadate have been prepared and studied for the first time. The sols were prepared by peptising ferric vanadate with caustic soda in presence of glucose and glycerine. The empirical formula for the glucose sol appears to be $19Fe_2O_3.2Fe(VO_3)_3.H_2O$ and of the glycerine sol $7Fe_2O_3.Fe(VO_3)_3.H_2O$. It will be seen from the results that the following points are very well characterised.

2. The conductivity of the glucose sol is very approximately proportional to the dilution showing that this particular sol did not undergo much hydrolysis during the process of dilution.

3. The glycerine sol contained comparatively a high content of vanadate. Its conductivity therefore did not decrease in the same proportion as the dilution. The product of conductivity and dilution is not constant. It showed a gradual increase as the dilution progressed.

4. The electrical conductivities of both the glucose and the glycerine sols are linear functions of temperatures. The temperature of zero conductance is $-23°$ in the glucose sol and $-28.5°$ in the case of the glycerine sol.

5. The temperature coefficient of conductivity per 1° for the glucose sol is 1.57% of the conductance at 35°, whilst for the glycerine sol it is 1.50% of the conductance at 35°.

6. The ageing-effect as studied by the conductivity values is equally prominent in both the sols. The conductivities increase as the time extends.

7. The extinction coefficients of the glucose sol are approximately proportional to the dilutions, whilst in the glycerine sol the extinction coefficients do not decrease in the same proportion as the dilution.

8. The p_H values of the dispersion medium lie between 7.21 and 7.48 showing that the sols are slightly basic owing to the stabilising hydroxide ions.

9. The sols obey the Schulze-Hardy rule for the coagulation with electrolytes. They show the normal behaviour on dilution.

THE CYANINE DYES OF THE PYRIDINE SERIES. PART IV.

By M. Q. Doja and Awadh Bihari Lal

Four new cyanine dyes have been prepared by the condensation of p-dimethylaminobenzaldehyde with α-picoline-secondary-propyl, -secondary-butyl, -isobutyl, and -isoamyl iodides; and their chemical, optical, dying and photographic properties examined. The influence of change of structure on the sensitising power of these and other related compounds has also been discussed.

In previous communications of this series, the influence on the photographic, optical and general properties of the valuable photosensitising compound (P), by the change in Z (Doja, *J. Indian Chem. Soc.*, 1940, **17**, 347), in Y (Doja and Prasad, *ibid.*, 1942, **19**, 125), and in X (Doja and Prasad, *ibid.*, 1942, **19**, 377) have been described. Previously when

$$\mathbf{X} \Big\rangle N - \langle \rangle - CH = CH - \langle \rangle \qquad \text{where } \mathbf{X} \atop \mathbf{Y} \Big\} = \text{alkyl radical}$$
$$\underset{\mathbf{Y}-\mathbf{N} \oplus}{\underbrace{}} \mathbf{Z} = \text{halogen atom}$$
$$\mathbf{Z} \ominus$$
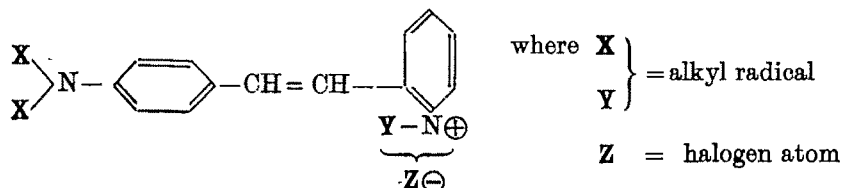
Y was changed, only straight-chained alkyl radicals were used; in the present paper, investigations and results are recorded in which Y has been replaced by branched chain alkyl radicals. Four different alkyl iodides, *e.g.* (1) secondary propyl, (2) secondary butyl, (3) *iso*butyl, and (4) *iso*amyl have been used for quaternising α-picoline. The quaternisation has been effected by heating equivalent quantities of the base and the alkyl iodide in a sealed tube in a boiling water-bath for 6 to 8 hours (*cf.* Murrill, *J. Amer. Chem. Soc.*, 1899, **21**, 828). In the case of the secondary-butyl iodide, the liquid reaction product had to be placed in a vacuum desiccator over sulphuric acid for a fortnight before crystals of α-picoline-secondary-butyl iodide could be obtained. These quaternary compounds, when condensed with p-dimethylaminobenzaldehyde in absolute alcohol (Mills and Smith, *J. Chem. Soc.*, 1922, **121**, 2736), produced the new cyanine dyes. Comparatively speaking, the secondary-propyl-(A) and the secondary-butyl-(B) dyes are more difficult to prepare than the corresponding *iso*butyl-(C) and the *iso*amyl-(D) dyes. (B) could only be obtained in the crystalline state, after two reprecipitations of the alcoholic solution by ether, and subsequent recrystallisation of the mass from absolute alcohol. (A) too had to be slowly evaporated for a long period before it could be induced to crystallise. On the other hand, both (C) and (D) readily crystallised out from the reaction mixtures on cooling. The period of heating of the reactants was also smaller in the latter cases, it being 4 and 2 hours for (C) and (D) and 6 and 5 hours for (A) and (B) respectively.

TABLE I

Compound	Structural difference.	Colour and shape of crystals.	M.p.	Reflex.	PLEOCHROISM One position.	PLEOCHROISM ⊥ position.	Relative intensity of colour in soln.	Relative to resistance decolorisation.	Extra sensitisation. Range.	Maximum.
A	H₃C—C(H)—CH₃ (N⁺)	Shining orange-red, felted small leaves	206-207°	Light yellow	Orange-brown	Weak yellow	1	1	5000-5750Å	510 0Å
B	H₅C₂—C(H)—CH₃ (N⁺)	Deep magenta, tiny needle clusters	165-67°	Bluish-green	Rose-red	Orange-red	1·07	0·93	4900-5850Å	5050Å
C	H₃C—C(CH₃)—C(H)—H (N⁺)	Mauve, microscopic granular crystals	265°	Light green	Claret-red	Nearly opaque	1·69	1·30	4850-5750Å	5200Å
D	H₃C—C(CH₃H)—C(H)—C(H)—H (N⁺)	Vermilion, small granular crystals	246-47°	Sky blue	Ruby-red	Nearly opaque	1·28	1·18	4800-5950Å	5250Å

(A), (B), (C) and (D) refer respectively to 2-*p*-dimethylaminostyryl-pyridine—secondary propyl iodide, secondary butyl iodide, *iso*butyl iodide, and *iso*amyl iodide.

Although α-picoline-secondary-propyl iodide and α-picoline-secondary-butyl iodide are both highly hygroscopic, the cyanine dyestuffs derived from them are not so.

The names, symbols, "distinguishing structural features," and some of the properties of these compounds are recorded in Table I. It will be noticed that in both (A) and (B), the quaternary nitrogen is attached to the secondary carbon atom of the alkyl radical, the two differing only in their size, (B) being one step higher in the homologous series than (A). The quaternary nitrogen atom in (C) is attached to a primary carbon situated next to the secondary carbon atom. In (D), the secondary carbon atom is farther removed, it being separated from the quaternary nitrogen by two intervening —CH₂— groups.

DOJA & LAL

unbathed plate

Sensitisation

Absorption

}(A)

}(B)

}(C)

}(D)

1607P
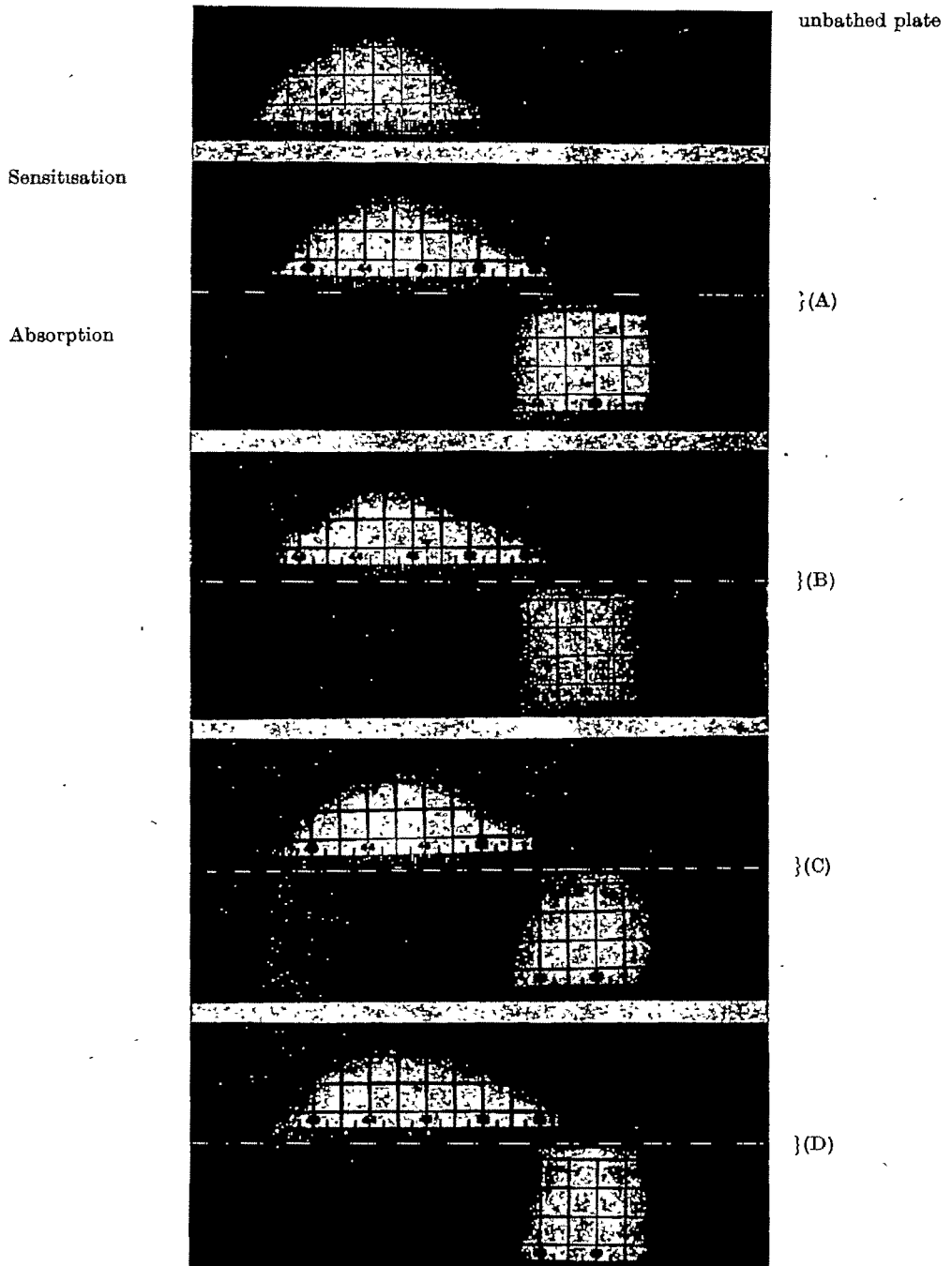
When the melting points of the two pairs of compounds : [(A), (B)], and [(C), (D)] are compared, it is interesting to note that both (B) and (D), although possessing higher molecular weights than (A) and (C) respectively, have lower melting points.

The crystals of all the four compounds are lustrous and highly coloured ; their colour, " reflex " and " pleochroism," are given in Table I. They are soluble in common ionising solvents and insoluble in the non-ionising ones. Their colour in solution (1 : 10,000) is orange, the secondary dyes being slightly lighter than the *iso*-dyes. On concentration (1 : 1000) the solution becomes redder and on dilution (1 : 100,000), more yellow. The " Relative intensity " of 1 : 10,000 solutions in rectified spirit of these compounds colorimetrically determined, is given in Table I.

Like other cyanine dyes, the solutions of these compounds are decolorised by the addition of mineral acids. The amount of acid required for complete decolorisation varies with the nature of the dyestuff. For this series, the "Relative resistance to decolorisation" of alcoholic solutions (1 : 10,000) by dilute hydrochloric acid is shown in Table I.

It will be seen that the *iso*butyl dye (C) is most resistant to decolorisation, and the secondary butyl dye (B) least so.

Silk, cotton and wool are dyed by these compounds an orange-yellow colour, the different shades produced are tabulated in Table II. The best colour is obtained on silk. In the case of cotton, an acid bath gives a more pronounced reddish tinge than a neutral bath. Comparatively the most intense colour is produced by (C), and the weakest by (B). In view of the minor structural difference between (B) and (C), both being butyl compounds, this difference is remarkable. The gradation of the intensity of colour produced by the different compounds is in the following order :

$$(C) > (D) > (A) > (B).$$

Although very pretty to look at none of these shades is fast either to washing or to sunlight.

In Table III is recorded the fluorescence of weak alcoholic solutions.

TABLE II

Colour produced on	Compound			
	A	B	C	D
Silk	Yellowish orange	Weak yellowish orange	Light orange	Orange yellow
Wool	Weak yellowish orange	Yellow	Orange	Yellowish orange
Cotton	Yellowish orange	Dirty orange	Deep orange	Deep orange

The colour on dilution (1 : 100,000) of these compounds was determined by a method described in an earlier communication (Doja, *J. Indian Chem. Soc.*, 1940, **17**, 348). The fluorescences, it will be noted, are very similar.

The sensitisation and absorption spectra of (A), (B), (C) and (D) are shown in Figure 1. The sensitisation spectra of all the four compounds are characterised by their high intensity, and the absence of the usual " gap " in the blue-green region of the spectrum. The *iso*amyl derivative (D), being the heaviest, has the longest extra-sensitisation band. The ranges and maxima of these sensitisation spectra are recorded in Table I.

When compared with the corresponding straight chain derivatives (Doja and Prasad, *J. Indian Chem. Soc.*, 1942, **19**, 125), the sensitisation spectra of these compounds are

not very much different; which means that the introduction of branched alkyl radicals in place of **Y** in the compound (P) does not materially alter the sensitising power of the compound.

<center>EXPERIMENTAL</center>

2- p- *Dimethylaminostyryl-pyridine-secondary-propyl   Iodide*   (A).—*p*-Dimethylamino-benzaldehyde (3 g.), α-picoline-secondary-propyl iodide (3.9 g.) and piperidine (1.0 c.c.), were dissolved in absolute alcohol (60 c.c.) and the solution boiled under reflux for 6 hours. The deep red solution was cooled, transferred to a crystallising dish, and slowly evaporated in a sulphuric acid vacuum desiccator for 6 hours. The separated crystals were recrystallised from absolute methyl alcohol, yield 1.2   g.   (20.5%). (Found : I, 32.14. $C_{18}H_{23}N_2I$ requies I, 32.25 per cent).

· 2-p-*Dimethylaminostyryl-pyridine-secondary-butyl Iodide* (B).—A solution of *p*-dime-thylaminobenzaldehyde (2 g.), α-picoline-secondary-butyl iodide (3.1 g.) and piperidine (1.0 c.c.), in absolute alcohol (30 c.c.), was gently boiled for 5 hours. The alcohol was evaporated off and the residual oily liquid again dissolved in alcohol and precipitated out with ether. After repeating this process twice, a semi-solid mass was obtained which yielded crystals after two recrystallisations from absolute alcohol, yield 1.25 g. (27.41%). (Found : I, 31.21. $C_{19}H_{25}N_2I$ requires I, 31.12 per cent).

<center>TABLE III</center>

Wallace colour Filter No.	Colour of the fluorescent beam seen at right angles to the incident beam			
	A	**B**	**C**	**D**
1	Light completely absorbed	Light completely absorbed	Light completely absorbed	Light completely absorbed
2	Very weak cherry red	Weak red	Pink	Cherry red
3	Light brinjal blue	Weak blue	Sky blue	Weak blue
4	Very weak orange	Weak orange	Orange	Orange
5	Sulphur yellow	Lemon yellow	Turmeric yellow	Turmeric yellow
6	Weak greenish yellow	Greenish yellow	Greenish yellow	Yellowish green
7	Grass green	Bottle green	Light green	Emerald
8	Brown	Brownish yellow	Brown	Brown
9	Dirty yellow (partly absorbed)	Dirty yellow	Weak dirty yellow	Weak dirty yellow
10	Dull yellow	Brownish yellow	Brownish yellow	Yellow

2-p-*Dimethylaminostyryl-pyridine*-isobutyl *Iodide* (C).—*p*-Dimethylaminobenzaldehyde (2 g.), α-picoline-*iso*butyl iodide (3.6 g.) and piperidine (1 c.c.) were dissolved in absolute alcohol (35 c.c.) and the solution refluxed for 4 hours. The solution on cooling deposited crystals, which were recrystallised from absolute methyl alcohol, yield 1.04 g. (19.6%). (Found : I, 31.28. $C_{19}H_{25}N_2I$ requires I, 31.12 per cent).

2-p-*Dimethylaminostyryl-pyridine*-isoamyl *Iodide*   (D).— α-Picoline-*iso*amyl iodide (2.8 g.), *p*-dimethylaminobenzaldehyde (1.5 g.), piperidine (1 c.c.) and absolute alcohol (30 c.c.), were heated together to a brisk boil for a couple of hours. The reaction mixture was allowed to cool and the separated crystals were filtered, washed with alcohol-ether and recrystallised from methyl alcohol, yield, 1.38 g. (33.4%). (Found : I, 30.16. $C_{20}H_{27}N_2I$ requires I, 30.08 per cent).

THE INTERACTION OF IODINE AND STARCH. PART I

By Sudhamoy Mukherjee and Sukhamoy Bhattacharyya

Titrations of solutions of amylose, potato starch and shoti starch with iodine have been carried out using a potentiometer and a photo-electric colorimeter respectively, for measuring the iodine activities and the intensities of colour, at different concentrations of starch and iodine and in the presence of different concentrations of potassium iodide. It has been shown that the photo-colorimetric titration can be used as a method for estimating the amylose contents of starches. The shapes of these titration curves are altered by changes in the concentrations of the reactants and of potassium iodide.

The iodine-complexes of starch and amylose have been precipitated from solution in the presence of different concentrations of iodine, potassium iodide and sodium chloride, washed with solutions of sodium chloride and sodium sulphate, and finally analysed for determining the starch-iodine ratio. This ratio has been found to remain practically unchanged in all these cases, the actual values ranging between 3.6 and 4.0 glucose units per atom of iodine. The significance of the results has been discussed and the formation of a chemical compound of starch and iodine in the precipitated complex has been suggested.

Since the interesting colour reaction between starch and iodine was first discovered by Stromeyer in 1813, there have been numerous investigations on the nature of this interaction, but a completely satisfactory explanation is not yet forthcoming. The earlier workers held divergent views on the subject and variously considered the starch-iodine complex to be (*i*) a chemical compound (*cf.* Mylius, *Ber.*, 1887, 20, 688 ; Rouvier, *Compt. rend.*, 1892, 114, 128, 749 ; Euler and Myrbäch, *Arkv Kem. Min. Geol.*, 1922, 8, No. 9, 1; *et seq*), (*ii*) a solid solution (*cf.* Küster, *Annalen*, 1894, 283, 360) or (*iii*) an adsorption complex (*cf.* Lottermoser, *Z. angew. Chem.*, 1921, 34, 427 ; 1924, 37, 84). They all considered the reaction of iodine with starch as a whole. But recent work of Meyer and co-workers (*Helv. Chim. Acta*, 1940, 23, 845) has shown that common starch is a heterogeneous substance, being made up of two components, amylose and amylopectin, differing from one another structurally and in their reactions with iodine. Amylose gives a pure blue colour and amylopectin, a reddish purple colour with iodine. This difference in reactivity with iodine has been utilised for estimating the relative proportions of these components in natural starches. Thus, Hassid and McCready (*J. Amer. Chem. Soc.*, 1943, 65, 1154) have developed a colorimetric method and Bates, French and Rundle (*J. Amer. Chem. Soc.*, 1943, 65, 142) an electrometric method for the estimation of amylose in starches, both being based on the differential reactivity of the starch fractions with iodine. On account of these researches, the study of the nature of the interaction between iodine and the individual fractions of starch has assumed increased importance.

Since it is now being generally accepted that the molecules of amylose consist of linear chains and those of amylopectin of a branched structure, attempts have been made to offer interpretations of the starch-iodine reaction in terms of molecular configuration. According to Freudenberg and co-workers (*Naturwissenschaften*, 1939, 27, 850), the amylose molecule has a helical structure, having a hydrocarbon-like interior in which iodine molecules can enter forming a solid solution. Rundle and co-workers (*J. Amer. Chem. Soc.*,

1944, **66**, 111, 2116) also confirmed the helical configuration of the amylose chain. From potentiometric and spectrophotometric titrations they concluded that iodine forms a true compound with the amylose component of starch, the composition remaining constant only when formed at a given iodide concentration. The iodine molecules are arranged linearly inside the helix parallel to its axis. Iodide or tri-iodide ions can enter the helix and replace iodine molecules and thereby alter the ratio between starch and iodine in the complex. They found that six to eight glucose units correspond to each atom of iodine in the complex, the lower figure representing the limiting value for zero concentration of potassium iodide. According to these authors, amylopectin forms a much less stable red complex, and the nature of this interaction resembles that of adsorption or solid solution.

While investigating the characteristics of a number of starch varieties, involving their fractionation, certain peculiarities in the reaction between starch and iodine were noticed by the present authors, which could not be explained on the basis of the existing theories. It was therefore considered to be of interest to pursue the subject further, with a view to throwing further light, if possible, on the nature of this interaction. Recourse has been taken to the use of a photo-electric colorimeter for following the course of the interaction between starch and iodine, by noting the changes in the intensity of the blue colour produced. Electrometric titrations of starch with iodine, as suggested by Bates, French and Rundle (*loc. cit.*) have been carried out for comparison. Another part of this work has been devoted to the precipitation and isolation of starch-iodine complex, prepared under a variety of conditions and determination of its composition by analysis.

EXPERIMENTAL

Starch Samples.—Potato starch was isolated from the raw tubers in this laboratory. Shoti (*Curcuma zeodoria*) starch was obtained by the courtesy of Messrs. Indian Research Institute, Ltd., Calcutta, and was purified by thorough washing. They were analysed for starch contents by the method given in A.O.A.C. (1939, p. 359). In all the tables given, the quantities of starch have been expressed in terms of the anhydrous starch contents as found by analysis.

Isolation of Amylose.—Amylose was isolated from potato starch by diffusion in warm water according to the procedure described by Hassid and McCready (*loc. cit.*). The anhydrous weight of the amylose has been used in all relevant calculations.

Potentiometric Titrations.—The starch (or amylose) was dissolved in dilute caustic potash solution, neutralised with dilute hydriodic acid and diluted with water so that the solution contained 0.01 to 0.04% of the starch and the concentration of potassium iodide was 0.05 N. This was titrated with a 0.001N solution of iodine containing 0.05N-potassium iodide, and the changes in iodine activity were followed by measuring the potentials of a bright platinum electrode dipped in the solution against a saturated calomel electrode, using a Leeds and Northrup potentiometer. The potentials have been plotted against the resulting concentrations of iodine in Fig. 1. The same figure also contains a blank titration curve of water containing 0.05N-potassium iodide with iodine of the same strength as used for the other titrations.

FIG. 1

Potentiometric titrations.

Resulting conc. of added $I_2(N \times 10^4)$.
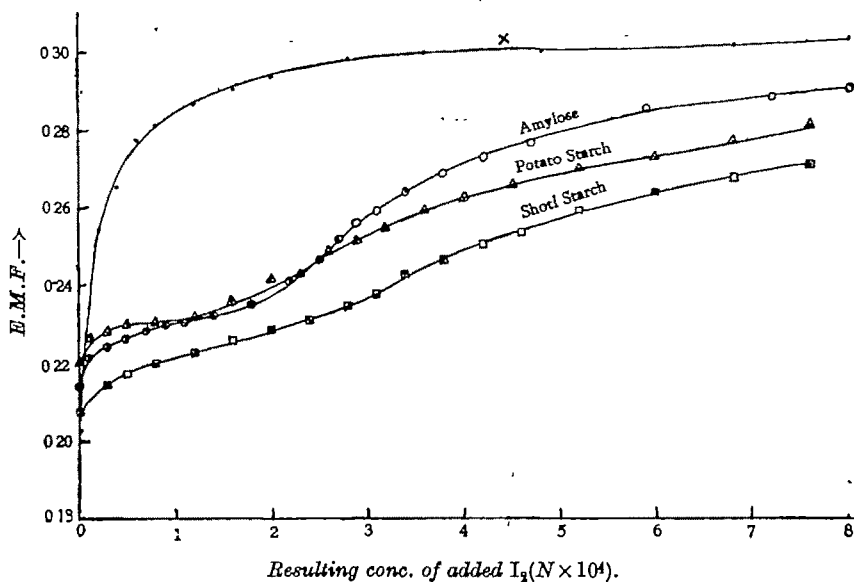
Titrations using Photo-electric Colorimeter.—The starch or amylose was made into a 0.01 to 0.04 % solution and titrated with a 0.001N solution of iodine, exactly as under 'potentiometric titrations,' but using a Klett-Summerson photo-electric colorimeter for measuring the intensities of colour during the titration. The curves obtained by plotting the colorimeter readings against the resulting concentrations of the iodine added are given in Fig. 3.

Another set of titrations of amylose and shoti starch with iodine was carried out using the photo-electric colorimeter, but under slightly different conditions as follows : The starch or amylose was dissolved in dilute caustic soda solution and the solution neutralised with hydrochloric acid, thus avoiding the introduction of iodide ions at this stage. The starch solution was made up to a strength of 0.001 to 0.002% and a 0.0157N solution of iodine containing 0.157N-potassium iodide was used for the titration. In some cases, known amounts of potassium iodide were added to the starch solution before titration in order to study the effect of different concentrations of this salt on the course of titration. These titration curves are shown in Fig. 4. The initial portions of these curves have been magnified in Fig. 5.

Isolation and Analysis of Starch-iodine Complex.—In the preliminary experiments potato starch, shoti starch and amylose (from potato starch) were employed. 0.5 G. of the amylose or 1.0 g. of the starch was dissolved in 20 ml. of a dilute solution of caustic soda and then acidified slightly with hydrochloric acid. To this was added 20 ml. of a 20% solution of sodium chloride and then 2.5 ml. of a 12% solution of iodine containing 20% potassium iodide. The starch-iodine complex was thrown down as a precipitate and the mixture was shaken up thoroughly for 5 minutes and then centrifuged. The supernatant liquid containing the free iodine was decanted off and the precipitated complex was washed with a further 50 ml. of 20% sodium chloride solution. This

was found to be adequate, as further washing with the salt solution failed to extract any further free iodine from the residue. The precipitate was washed out with 15 ml. of an $N/10$ solution of sodium thiosulphate and the suspension titrated with an $N/10$ solution of iodine.

FIG. 2

Resulting conc. of $I_2(N \times 10^4)$.
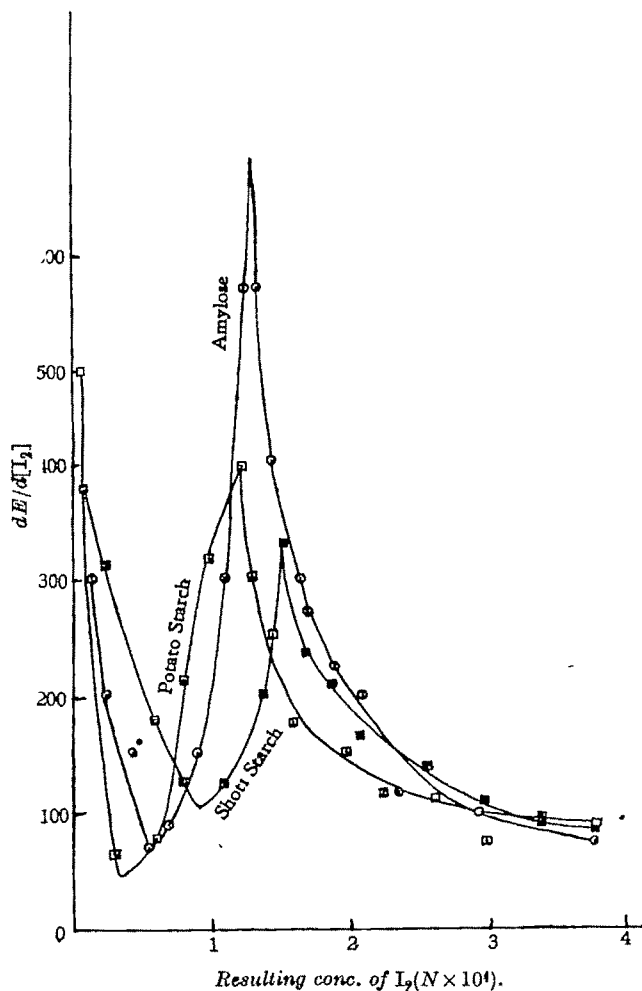
Similar experiments were then carried out under three different conditions, namely,

(*i*)   precipitation of the complex in the presence of varying concentrations of potassium iodide and washing the precipitate with a 20% sodium chloride solution;

(*ii*)   precipitation in the presence of varying concentrations of sodium chloride* and washing with a 20% sodium chloride solution; and

(*iii*)   precipitation in the presence of varying concentrations of potassium iodide and washing with a 10% sodium sulphate solution.

. * The reaction mixture contained potassium iodide at a concentration of 0.043N, this being derived from the iodine solution added for the interaction.

FIG. 3

Photo-colorimetric titrations.
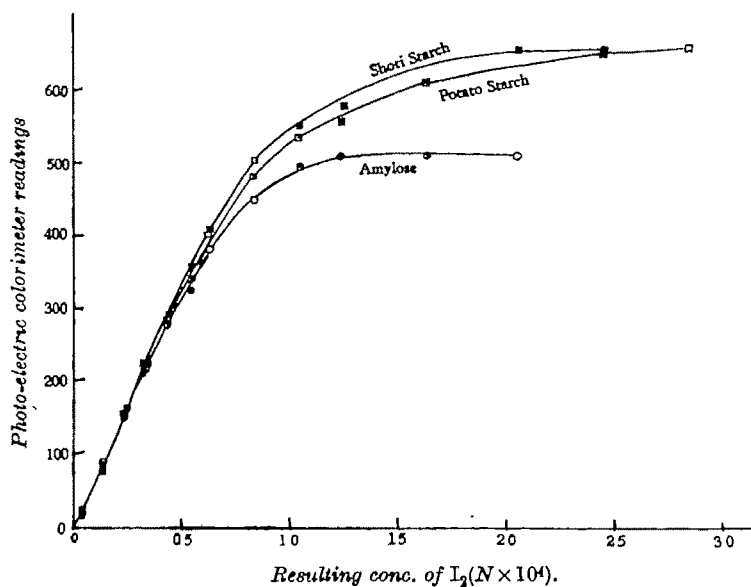
FIG. 4
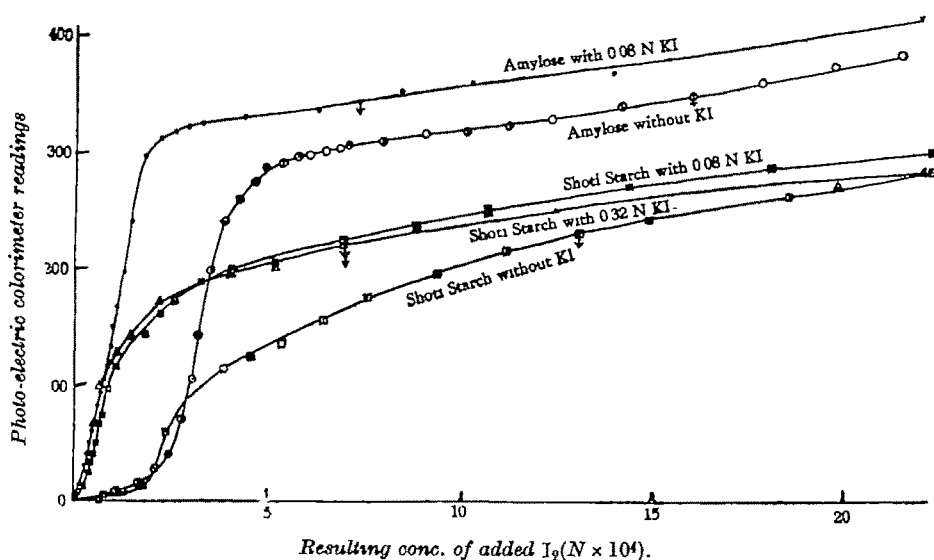
For (*i*) and (*iii*) the starch was dissolved in a 10% caustic potash solution which was subsequently neutralised with hydriodic acid. For (*ii*) the starch was dissolved in a 10% caustic soda solution and the solution neutralised with hydrochloric acid. Iodine was added in the form of a 12% solution containing 20% potassium iodide, and 2.5 ml. of the solution were added in each case. Potassium iodide or sodium chloride was added at this stage, in the form of a concentrated solution, sufficient to raise the concentration of the salt to the desired level. When the complex was formed in the

presence of relatively low concentrations (0.046N and 0.176N) of potassium iodide, the precipitation of the complex was incomplete. In order to produce complete precipitation, the same salt, as was used subsequently for washing the precipitate *viz.*, sodium chloride or sodium sulphate, was added in solid form. The resulting concentration of the salt was 5% and 3% respectively for solutions containing 0.046N and 0.176 N-potassium iodide. The complex, which was now thrown down as a precipitate, was separated from the solution by centrifuging. The supernatant liquid in the centrifuge tubes was decanted off and the precipitate was washed with 50 ml. of the salt solution. Washing was done only once in series (*i*) and (*ii*) as in the previous experiment, but in (*iii*) the precipitate was washed three times with sodium sulphate solution. In each washing, the sediment was mixed thoroughly with the salt solution, the suspension was centrifuged and the supernatant liquid decanted off.

FIG. 5

Resulting conc. of added $I_2 (N \times 10^4)$
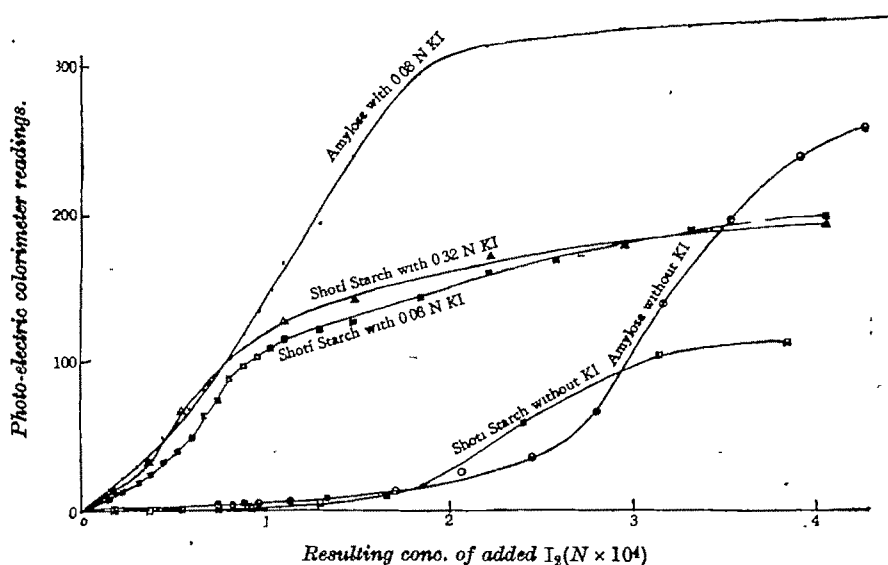
The precipitate was washed out of the tubes using 15 ml. of a 0.1 N solution of sodium thiosulphate and this suspension was titrated with a 0.1N solution of iodine.

For calculating the ratio of starch to iodine in the complex, it was assumed that all the starch, taken initially, was present in the precipitated complex. In order to test the correctness of this assumption, two experiments were made in which the precipitated starch-iodine complex, after being taken in the sodium thiosulphate solution, was analysed for starch by acid hydrolysis method. The results given in Table III show good agreement between the quantities of starch taken and those found by analysis of the complex. Consequently, no further determinations of starch in the final suspensions were made in the other experiments.

In series (*i*) and (*ii*), only potato starch was used, but in series (*iii*), both amylose and potato starch were employed. The results of these experiments are given in Tables IV and V.

In the experiments of series (*i*) to (*iii*), varying amounts of water had to be added to bring the concentrations of the added salts to the desired levels, and this resulted in

a variation of the concentration of iodine in the reaction mixture. In Table V, these concentrations of iodine have also been given.

TABLE I

Potentiometric and photo-colorimetric titrations of starch with iodine.

Conc. of iodine=0.001 N.   Vol. of titrant=50 ml.

Mode of titration.	Variety of starch (or amylose).	Quantity of starch taken.	Quantity of iodine combining at the end-point.	Ratio of Iodine : starch at end-point.	No. of glucose units per atom ot iodine.	Amylose content.
Potentiometer	Amylose	0.0052 g.	0.000803 g.	0.155	5.07	100%
,,	Potato starch	0.0161	0.000751	0.047	16.85	30.32
,,	Shoti starch	0.0173	0.000919	0.053	14.79	34.20
Photo-electric colorimeter	Amylose	0.0025	0.000380	0.152	5.16	100
,,	Potato starch	0.0076	0.000334	0.044	17.83	28.94
,.	Shoti starch	0.0076	0.000327	0.043	18.22	28.28

TABLE II

Photo-colorimetric titration.

Conc. of iodine=0.0157 N.   Vol. of titrant=500 ml.

Titration curve No.	Conc. of KI added.	Variety of starch (or amylose).	Quantity of starch taken.	Quantity of iodine added at colour transition.	Ratio of iodine : starch at the colour transition.
1	Nil	Amylose	0.00501 g.	0.0086 g.	1.72
2	0.08 N	,,	,,	0.0040	0.80
3	Nil	Shoti starch	0.00595	0.0061	1.03
4	0.08	,,	,,	0.0038	0.64
5	0.32	,,	,.	0.0038	0.64

TABLE III

Expt.	Starch taken.	Quantity of starch found.
(A)	0.857 g.	0.855 g.
(B)	0.687	0.670

TABLE IV

Analysis of starch-iodine precipitate.

Quantity of starch (or amylose) taken.	Quantity of iodine found by titration.	No. of glucose units per atom of iodine.
Amylose (0.4133 g.)	0.0889 g.	3.82
Potato starch (0.7326 g.)	0.1431	4.00
Shoti starch (0.6806 g.)	0.1372	3.90

TABLE V

Starch-iodine ratios in amylose and potato starch-iodine complexes.

Amylose content of starch=27.2%

Potato starch-iodine. precipitated in presence of KI. Washed with NaCl.			Potato starch-iodine. Precipitated in presence of NaCl. Washed with NaCl			Potato starch-iodine. Precipitated in presence of KI. Washed with Na_2SO_4			Amylose-iodine. precipitated in presence of KI. Washed with Na_2SO_4		
(1)			(2)			(3a)			(3b)		
Conc. iodine.	Conc. KI.	No. of glucose units.*	Conc. iodine.	Conc. NaCl.	No. of glucose units.*	Conc. iodine.	Conc. KI	No. of glucose units.*	Conc. iodine.	Conc. KI	No. of glucose units
0.078 N	0.176N	3.71	0.045 N	0.85 N	3.60	0.026 N	0.046 N	3.83 3·84	0.012N	0.046 N	3.94
0.059	0.450	3.66	0.033	1.70	3.65 3.75 3.65	0.065	0.176	3.67 3.75	0.025	0.176	3.76
0.047	0.530	3.75 3.67	0.027	2.44	3.67 3.74 3.67	0.058	0.530	3.94 3.83	..	..	..
0.039	1.210	3.86 3.79	0.027	3.30	3.70	0.035	1.210	3.90 3.90	0.033	1.210	3.94
Mean	..	3.74	..	..	3.67	..	..	3.84	..	..	3.88

* Per atom of iodine.

DISCUSSION

Potentiometric and Photo-colorimetric Titrations.

The potentiometric titration curves for amylose and starches in Fig. 1 have distinct inflexions, which may be taken to represent the end-points of the amylose-iodine reaction. The corresponding $dE/d[I_2]$—$[I_2]$ curves (in which E represents the E.M.F. and $[I_2]$ the concentration of iodine) given in Fig. 2 enable one to locate the inflexion points. Bates, French and Rundle (*loc. cit.*), who also obtained similar titration curves, assumed the point where the slope first showed a rapid rise as the end-point of the amylose-iodine reaction. But subsequently Baldwin, Bear and Rundle (*J. Amer. Chem. Soc.*, 1944, **66**, 111) who observed discrepancies between the results obtained by potentiometric and spectrophotometric titrations, remarked that the complex formation is not completed at this point, on account of the partial dissociation of the complex near the saturation point. It appears, however, that it would be more appropriate to take the inflexion points as representing the end-points, as is done in the potentiometric (p_H) titration curve of a moderately strong acid with an alkali where partial hydrolysis of the salt takes place near the equivalence point. The uncombined iodine left in the system at this inflexion point can be estimated with the help of curve ' X ' in Fig. 1. The quantity of iodine actually entering into combination with the amylose at the inflexion point can therefore be obtained by deducting the uncombined iodine from the total amount of iodine added at this point. If it be assumed, as has been done by Bates, French and Rundle (*loc. cit.*), that only amylose reacts with iodine up to this point and that consequently the amounts of iodine combining with a

given quantity of starch are proportional to the amylose contents, the latter can be calculated from the potentiometric titration curve by comparing it with that for pure amylose. The ratios of starch to iodine at the inflexion points and the amylose contents of potato and shoti starches calculated in this manner have been given in Table I.

The titration curves in Fig. 3, obtained by using the photo-electric colorimeter, and under the same conditions as in the potentiometric titrations, also show breaks in their slopes. The curves rise almost linearly in the initial stages, then take a sharp bend and finally run nearly flat. Supposing that only amylose reacts with iodine in the initial stage, the steep rise in the titration curve would represent the formation of the blue amylose-iodine complex. In such a curve, the end-point would be represented by the point of intersection of the initial and final slopes. Obtaining the end-points in this manner and proceeding on the same lines as before, the percentages of amylose in potato and shoti starches have been calculated and given in Table I.

Comparison of the two sets of figures in Table I for the amylose contents of potato and shoti starches shows a small difference. Mukherjee and Bhattcharyya (*J. Indian Chem. Soc., Ind. & News Ed.*, 1945, **8**, 4) obtained the values 27.2% and 31.3% respectively for the amylose contents of potato and shoti starches by following a colorimetric method which is a slight modification of that described by Hassid and McCready (*loc. cit.*). It thus appears that titration with iodine using the photo-electric colorimeter may be regarded to constitute an additional method for the determination of the amylose contents of starches. It will, however, be noticed from a study of the titration curves in Figs. 1 and 2 that the curves for amylose show sharper breaks or inflexion points than those for the starches investigated. This difference would indicate the possibility of the other constituent of starch, *i.e.*, amylopectin, taking some part in the reaction.

Baldwin, Bear and Rundle (*loc. cit.*) stress the necessity of using low concentrations of iodine for spectrophotometric titrations, as the iodine then first forms a complex with amylose alone and the molecular extinction coefficient is nearly independent of the amylopectin impurity. Another set of titrations was therefore carried out with still lower concentrations of starch, *viz.*, 0.001 to 0.004% and under such conditions that the concentrations of iodine in the starch solution during the titration were of a much lower order than in the previous titrations. These titrations were also carried out in the presence of varying concentrations of potassium iodide (*vide* Fig. 4). The curves for amylose and shoti starch (Fig. 4), obtained without the addition of potassium iodide, show significant differences in shape from the corresponding curves in Fig. 3. In the initial stages the curves remain flat but rise subsequently and pass through inflexion points, finally becoming flat again. The initial flat portion (*vide* also Fig. 5) indicates either the absence of interaction or the formation of a colourless complex, at these low concentrations. But the slight rise in iodine activity in the initial stages of the potentiometric titration curves (Fig. 1) suggests that the former supposition is probably correct.

In the presence of potassium iodide (*vide* curves in Fig. 4) the initial flat portion is abbreviated, so that the curves rise steeply from the beginning of the titration. This shows that the potassium iodide facilitates the reaction between amylose and iodine at extremely low concentrations of the reactants, where normally no interaction would take place in its absence.

The presence of potassium iodide not only increases the initial slope but at the same time enhances the maximum intensity of colour attained during the titration. This is in accord with the observations of Baldwin, Bear and Rundle (*loc. cit.*) made by spectrophotometric titrations of amylose.

It was noticed during these titrations that the light blue colour, produced by the first addition of iodine, grows deeper as the titration proceeds and at a certain stage the colour changes to a greenish shade. This change can be detected within 0.25 ml. of the iodine added. The points at which the transition of colour was noticeable have been marked with arrows in the titration curves in Fig. 4. The change from blue to green colour may be produced by the superposition of the blue colour of the amylose-iodine complex and the yellow colour of free iodine, which would be expected to be present in the system after the formation of this blue complex is complete. If this supposition were correct, these transition points would give a measure of the amylose contents of starches. Calculations of the ratios of iodine to starch, calculated from the points of colour transition, given in Table II, however, fail to show a direct correspondence between these and the corresponding ratios given in column 5 of Table I.

If the amylose-iodine complex be regarded as a chemical compound, a definite stoichiometric relationship between the reactants should be expected. The number of glucose residues (of amylose or starch) corresponding to each atom of iodine, calculated at the end-points of the titration curves in Figs. 1 and 3, are given in column 6 of Table I. The figures for amylose calculated from the potentiometric and the photo-colorimetric titration curves in the presence of 0.05N-potassium iodide come to 5.07 and 5.16 respectively. The corresponding figures, found by Rundle and co-workers (*loc. cit.*) from potentiometric and spectrophotometric titrations of amylose in the presence of 0.05N-potassium iodide are 7.2 and 8.4 respectively. In both sets of figures the optical methods are found to give higher values than those obtained by the potentiometric method, but the difference in magnitude between their values and those obtained here could not be explained. The low values of the ratio found in our experiments are significant in view of the fact that according to the hypothesis put forward by Rundle and co-workers (*loc. cit.*) six is the minimum number of glucose units corresponding to each atom of iodine in the complex attainable at infinite dilution of potassium iodide.

Isolation of the Starch-iodine Complex.

The results obtained by the isolation and analysis of the starch-iodine complex (Tables IV and V) provide more direct evidence for the ratio of starch to iodine in the complex. Since amylopectin is considered to have a much weaker affinity for iodine than amylose (Rundle and co-workers, *loc. cit.*) and common starches contain a much higher proportion of amylopectin than of amylose, these starches would be expected to form complexes with iodine having larger starch-iodine ratios than amylose itself. But the figures in Tables IV and V show that this ratio for both potato and shoti starches are almost identical with that for amylose, the actual values ranging between 3.6 and 4.0 glucose units per atom of iodine. It will, however, be noticed that in series 3(*a*) and (*b*), where the washing of the precipitate was more complete, most of these figures approach nearer to the upper limit. Further, these values

are significantly lower than those found by potentiometric and photo-colorimetric titrations of amylose solutions.

Influence of Potassium Iodide.—It has already been shown how the presence of iodide ions influences the shapes of the titration curves of starch solutions with iodine. Rundle and co-workers (*loc. cit.*) postulated that iodide ions can penetrate into the complex and displace iodine molecules. This would result in an increase of the starch-iodine ratio, and the above authors found this ratio to be as high as 8 glucose units per atom of iodine in the presence of $0.05N$-potassium iodide. In the present series of experiments the concentration of potassium iodide in the starch solution at the time of precipitation of the complex was varied between the limits $0.043N$ and $1.21N$, but, as the results in Table V show, this had no perceptible effect on the starch-iodine ratios of the precipitated complex.

Influence of other Salts.—The starch-iodine complex, after precipitation, had to be washed free from any iodine mechanically adhering to it, but the use of water was not practicable on account of the peptisation of the coagulum when washed with water. Sodium chloride (20%) was therefore used in the preliminary experiments (Table IV) as well as in series (*i*) and (*ii*).

In order to find out if the concentration of sodium chloride used would have any effect on the composition of the complex, in series (*ii*) the concentration of potassium iodide was kept constant at $0.043N$, while that of sodium chloride was varied between $0.85N$ and $3.30N$. It will be seen from Table V that no detectable variation of the starch-iodine ratio resulted from these alterations.

Again, in series (*iii*) of the experiments, sodium chloride was replaced by sodium sulphate in order to see if the divalent SO_4'' ion would have any influence. But the results fail to show any marked change in the starch-iodine ratio by this treatment. In fact, the average value of this ratio in series (*iii*) was 3.86 as against 3.74 and 3.67 glucose units per atom of iodine for series (*i*) and (*ii*) respectively.

Influence of the Concentration of Iodine.—In the experiments carried out under series (*iii*), the iodine concentration was varied in the reaction mixtures between the limits $0.012 N$ and $0.078 N$. But it will be found from Table V that these changes did not affect the composition of the complexes.

Further work on this problem is in progress.

CONCLUSIONS

1. The interaction between iodine and starch has been studied in the solution phase, by potentiometric and photo-colorimetric titrations and in the solid phase by salting out the starch-iodine complex and analysing the precipitate.

2. In the interaction of starch and iodine in solution, only the amylose component appears to combine with iodine. The course of the interaction and the end-points of the titrations are altered by the presence of iodide ions. Interchange between iodine molecules in the complex and iodide ions in solution, as suggested by Rundle and co-workers (*loc. cit.*), possibly takes place, resulting in a variation of the starch-iodine ratio of the complex.

3. The starch-iodine complex, in the solid-phase, *i.e.*, in the precipitated condition, shows, in contrast to its behaviour in solution, a remarkable constancy of composition. The ratio of starch to iodine remains practically independent of the concentrations of iodine, potassium iodide and/or of the other salts present in the system at the time of formation or of washing the precipitate.

4. In the precipitated condition, the iodine-complexes of both amylose and whole starch show an identical starch-iodine ratio. The mean value of this ratio is near about 4.0 glucose units for each atom of iodine. This value is lower than that obtained for amylose by potentiometric or photo-colorimetric titrations in the solution phase.

5. The difference in reactivity between amylose and amylopectin towards iodine is being generally attributed to the difference in their molecular structure, *i.e.*, in the lengths of the glucose chains. The observation recorded in the preceding paragraph indicates that under the conditions of precipitation of the starch-iodine complex, changes occur which practically obliterate the effects of these structural differences and the two starch components, amylose and amylopectin, behave similarly in their interaction with iodine.

6. The constancy of the composition of the precipitated starch-iodine complex indicates some sort of chemical combination in a definite stoichiometric ratio in the interaction between iodine and starch. The approximate formula of the complex may be written as $(C_6H_{10}O_5)_{8n}I_{2n}$.

PARACHOR OF FUSED RING STRUCTURE

By P. C. Guha and S. C. Bhattacharyya

Parachors of bicyclo-(2 : 2 : 2)-octane–dione dicarboxylate and bicyclo-(3 : 2 : 2)-nonane-dione dicar-
boxylate have been determined. The compounds possess bicyclic ring structure containing 4 and 5
common carbon atoms, respectively. Both the compounds show a negative anomaly of about 4 to 6
units indicating thereby that the rings are in a strainless condition, probably possessing boat-shaped
structures. Actual carbon models of these compounds support this assumption.

Evaluation of parachor has been widely used in characterising organic compounds.
Work has also been done about the parachor of fused ring structure containing two or three
carbon atoms common to more than one of the rings (Deshapande et al., J. Indian Chem.
Soc., 1942, 19, 157 ; Ray, ibid., 1935, 12, 764 ; Guha, ibid., 1944, 21, 339). But little or
no information is available about the parachor of fused ring structure containing four or
five common carbon atoms. This class of compounds is not easily available and is
rather difficult to prepare. A determination of the parachor of these compounds is there-
fore interesting as it will throw some light on the stereochemical orientation and spatial

configuration of these molecules. In this paper the parachors of the following two compounds have been determined.
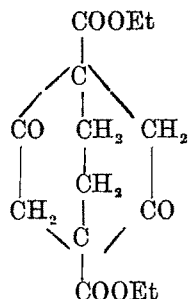
Bicyclo-(2:2:2)-octane-dione dicarboxylate (I)
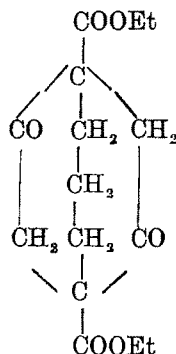
Bicyclo-(3:2:2)-nonane-dione dicarboxylate (II)

The compounds were obtained according to the method of Guha (*Ber.*, 1939, **72**, 1359). The compound (I) contains two fused six-membered rings with four common carbon atoms and the compound (II) is constituted of two fused seven-membered rings with five carbon atoms common to both the rings. As the substances are solid, surface tension was determined by maximum bubble-pressure method in nitrobenzene solution. To ensure the accuracy of the results, the instrumental constant was checked with pure anhydrous benzene before each measurement. Density was determined with a small pyknometer and parachor was calculated according to the equation of Hammick and Andrew (*J. Chem. Soc.*, 1929, 755).

Thus

$$P_m = P_s (1 - x) + P_x . x \qquad \dots \quad \text{(I)}$$

$$P_m = \frac{M_m}{D-d} \gamma^{\frac{1}{4}} \qquad \dots \quad \text{(II)}$$

$$M_m = M_s (1 - x) + M_\lambda x \qquad \dots \quad \text{(III)}$$

where P_m = parachor of solution, P_x = parachor of the solute, P_s = parachor of the solvent, x = molar fraction of the solute, $(1-x)$ = molar fraction of the solvent, M_m = mean molecular weight, D = density of the solution, γ = surface tension of the solution, M_s = molecular weight of the solvent, M_λ = molecular weight of the solute. Mean parachor of nitrobenzene as determined with our instrument is 263.1. The value of 'g' at Bangalore was taken as 978. The parachor constant for a seven-membered ring was taken as 4.2 (Godchot, *Compt. rend.*, 1931, **192**, 1560). A five-figured log-table was used in these calculations, because a small change in the value in P_m affects the result considerably. The density of the solutions of these compounds shows some unusual peculiarities which has been discussed at the end.

TABLE I

Parachor of bicyclo-(2 : 2 : 2)-octane-dione dicarboxylate in nitrobenzene solution.

$P_{calc.} = 593.6.$

Temp.	Density.	γ.	M_m.	P_m.	P_x.
			$x = 0.0158$		
30°	1.1941	42.35	125.5	268.10	589.1
40	1.1842	40.96	,,	268.11	590.2
50	1.1743	39.60	,,	268.09	588.5
			$x = 0.03718$		
30°	1.1941	42.12	129.0	275.22	588.92
40	1.1844	40.75	,,	275.18	588.00
50	1.1746	39.49	,,	275.32	591.70
			$x = 0.05121$		
30°	1.1943	42.024	131.27	279.85	590.1
40	1.1845	40.654	,,	279.82	589.6
50	1.1747	39.242	,.	279.69	587.1

Density-molar ratio relation

	Density at		
x.	30°.	40°.	50°.
0.01528	1.1941	1.1842	1.1743
0.03718	1.1941	1.1844	1.1746
0.05121	1.1943	1.1847	1.1747

TABLE II

Parachor of bicyclo-(3 : 2 : 2)-nonane-dione dicarboxylate.

$P_{calc.} = 628.80$

Temp.	Density.	γ.	M_m.	P_m.	P_x.
			$x = 0.01621$		
30°	1.1944	42.36	125.91	268.94	622.8
40	1.1843	40.93	,,	268.91	621.4
50	1.1747	39.60	,,	268.88	620.1
			$x = 0.04012$		
30°	1.1944	42.21	130.06	277.55	623.1
40	1.1845	40.83	,,	277.55	623.1
50	1.1748	39.54	,,	277.60	624.4

Density-molar ratio relation

	Density at		
x.	30°.	40°.	50°.
0.01621	1.1944	1.1843	1 1747
0.04012	1.1944	1.1845	1.1748

It is seen from the above results, that in the experimentally determined values of their parachor, both the compounds show a negative anomaly of about 4 to 6 units. This is an indication of the fact that these compounds exist in a strainless condition (Sugden, "Parachor and Valency", 1930, p. 44). In conformity with the work of Mohr (*J. prakt. Chem.*, 1918, **98**, 315 ; 1922, **103**, 396) and others about strainless structure

of *cyclo*hexane derivatives, the following strainless boat-shaped structures are therefore suggested for these compounds.
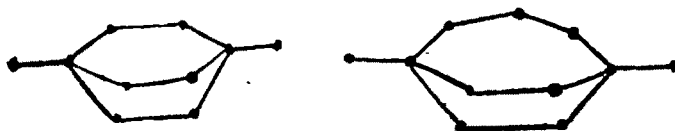
This suggestion is borne out by the fact that the actual carbon models of these compounds show similar orientation of the ring structure. One unusual peculiarity has been observed about the densities of these compounds. Though the amount of substance dissolved might vary considerably (1 : 5), the density at any particular temperature remained nearly identical. Thus the density remains almost unaffected by the amount of substance dissolved. This shows that by dissolving the substance in nitrobenzene, the volume adjustment takes place in such a way that the mass per unit volume at a particular temperature remains nearly constant.

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CONDENSATION OF ALDEHYDES WITH MALONIC ACID. PART XVII. CONDENSATION OF p-DIMETHYL-AMINOBENZALDEHYDE

By Kantilal C. Pandya and Hari Narayan Sharma

' The influence of the amino group has been investigated in the aldehyde-malonic acid condensation. The expected inhibitive character is seen. With p-dimethylaminobenzaldehyde, no condensation is found to take place by the usual method of the 0.15 mol. of pyridine under various conditions. Use of excess of pyridine, up to three mols. gives a poor yield. With a trace of piperidine, however, the yield rises to 55% which increases still further when a pyridine-piperidine mixture is used, the highest yield of about 80% is obtained by applying Vorsatz's method. The related dibasic acid cannot be isolated inspite of several attempts, which again points to the inhibitive character of the group.

The previous parts of this series have been concerned with the investigation, not only of the influence of pyridine and other bases on the aldehyde-malonic acid condensation, but also of the influence of various groups occurring on the ring of the aromatic aldehyde on the same condensation. In this way the hydroxy and, to some extent, the methyl groups are found to be decreasing the yield, and the methoxy, the methylene-dioxy, the nitro, the chloro and the bromo groups are found to be, more or less, increasing the yields of the condensation products. In fact, the reactions,

$$R.CHO + H_2C(COOH)_2 \rightarrow R.CH:C(COOH)_2 \rightarrow R.CH:CH.COOH$$
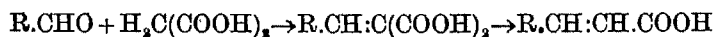
(where R = Ph), are tremendously influenced, not only by the ordinary conditions of the reaction (such as the temperature at which the reaction is carried out, the time of keeping or heating, the presence or the absence of organic bases like pyridine], but also by the nature of the group or groups, and their position and number, that may be present in the ring. This influence is clearly marked on the speed of the reactions, on the yield of the condensation product and, to an extent, on its purity.

The amino group has not so far been included, either in this survey of the aldehyde-malonic acid condensation or in that of Perkin's reaction (Lock and Bayer, *Ber.*, 1939, **72**, 1064). One possible reason is the greater difficulty of preparing the aminobenzaldehydes in a pure condition, and the other is certainly the alleged inhibitive nature of the amino group itself.

The condensation of *p*-dimethylaminobenzaldehyde has been studied in this paper. Weil (*Monatsh*, 1908, **29**, 895) reports that *p*-dimethylaminocinnamic acid may be obtained by using the Perkin's reaction with the aldehyde, preferably when potassium acetate is used in place of sodium acetate in the condensation. Meyer and Beer (*ibid.*, 1913, **34**, 649) confirm this, adding that the reaction takes place only in the presence of potassium acetate, and not in the presence of sodium acetate. Thoms and Seebe (*Z. angew. Chem.*, 1926, **39**, 1496) have concluded that the introduction of the *p*-dimethylamino group reduces the reactivity of benzaldehyde in cinnamic acid synthesis and causes a tendency to give by-products. Hinkel and Cremer (*J. Chem. Soc.*, 1920, **117**, 137) also report on its retarding effect, as expected, in Hantzsch's-pyridine synthesis.

The expected difficulty was realised in the present condensation; no condensation product was obtained in the usual water-bath condensation with a small trace of pyridine (1: 1 : 0.15 mol.). Increase in the period of heating or decrease in the temperature of the water-bath down to 60°, when the reactants became a homogeneous liquid, effected no improvement. Increase in the amount of malonic acid gave no yield, resinification often taking place and much of the aldehyde being recovered unchanged. Absolute alcohol and absolute alcohol with hydrochloric acid were used to check resin-formation, together with a trace of pyridine ; a yellow turbid solution was obtained, suggesting some condensation, but no solid could be separated. More of pyridine was used ; with one mol. of pyridine, about 2% of the expected product came out ; with 3 mols., 5.3% came out. Piperidine was then substituted, and then the yield went up to 55%. Robinson and Shinoda's pyridine-piperidine mixture and refluxing on a wire-gauze (*J. Chem. Soc.*, 1925, 1977), gave 60% yield. A pyridine-piperidine mixture (1 : 1 : 3 : a few drops) gave on 8 hours' heating on a water-bath 73.3% yield. The best yield was obtained by following Vorsatz's method (*J. prakt. Chem.*, 1936, **145**, 265) by keeping the mixture (1 : 2 : 6 : 0.15) at room temperature for three weeks, when the yield rose to over 79% (*vide* Experimental).

While the difficulty in the condensation was overcome by various means, the condensation that should produce the undecarboxylated dibasic acid did not meet with equal success. All possible methods were tried but *p*-dimethylaminobezylidenemalonic acid could not be isolated , much resin and unchanged aldehyde were generally obtained.

EXPERIMENTAL

Condensation in the presence of Pyridine.—p-Dimethylaminobenzaldehyde (0.75 g.), malonic acid (0.52 g.) and pyridine (0.07 c.c.) (1 : 1 : 0.15 mol.) were heated together on a water-bath. In three minutes the whole mixture became a homogeneous liquid and within ten minutes effervescence started, the colour becoming green soon after. But the colour rapidly changed to greenish yellow, brown and ultimately dark red. Effervescence stopped after two hours but no solidification took place. After 5 hours' heating the mixture was cooled overnight. Reddish resinous material when treated with sodium carbonate solution gave a brown precipitate, which was found to be the unchanged aldehyde. The alkali extract gave nothing on acidification. The aldehyde recovered was about 0.5 g. It appears as if the effervescence was due only to the breaking down of the malonic acid.

Three more experiments with slight alterations, such as heating for 8 hours on a water-bath, with 2 mols. of malonic acid, and heating at 60° with 3 mols. of malonic acid, did not bring about any change in the result. In the next experiment absolute alcohol was taken also (1 : 1 : 15 : 0.15 mols.) and the heating was done on a water-bath with a reflux condenser for 5 hours. A yellow turbid solution was obtained, suggesting that a slight reaction had taken place. The same experiment was repeated with the addition of 1 c.c. of concentrated hydrochloric acid. The result was the same.

Larger amounts of pyridine effected the condensation. Thus with a molecular proportion of pyridine (1 : 1 : 1 mol.), a little yellow precipitate came out, melting at 211° and identifiable with the expected p-dimethylaminocinnamic acid, yield 2% of theory. With 3 mols. of pyridine for one of the aldehyde and one of the acid, the yield was 5.3%. The product melted at 212° with decomposition.

Condensation in the presence of Piperidine.—With a trace of piperidine the mixture was heated on a water-bath for 5 hours. Effervescence commenced in 10 minutes and the colour became blood-red. After an hour a solid began to separate, and complete solidification was apparent in 2 hours. The heating was stopped after 5 hours and the flask was left overnight. The beautiful red solid mass was treated as usual, the unused aldehyde was removed with ether, and the bright yellow precipitate, obtained on acidifying the solium salt extract, was filtered, dried and recrystallised from alcohol, the final m.p. was 216°, yield 55%. Increase in the amount of piperidine by doubling it brought no increase in the yield, but the additional use of absolute alcohol as before gave the yield up to 62.8%.

Condensation in the presence of Pyridine-piperidine Mixture.—Reactants in the molecular proportion [1: 1 : 3 (pyridine) : 0.15] were heated on a water-bath for 8 hours : the yield was 73.3%.

Robinson and Shinoda's method (*loc. cit.*) gave 60% yield. While Vorsatz's method (*loc. cit.*) gave the best yield of 79.6% of theory (0.75 g. aldehyde, 1.0 g. acid, 2.4 c.c. pyridine and 0.05 c.c. piperidine, at room temperature, 10-21°. for 3 weeks.)

Condensation in the presence of Sodium Ethoxide.—The aldehyde (0.75 g.), malonic acid (0.5 g.) were added to a mixture of 0.04 g. sodium in 3 c.c. of absolute alcohol. The well-corked flask was kept aside for 6 weeks. After one week a little yellow crystalline

product began to separate. The product, taken out after six weeks, was almost pure, but the yield was only about 16%.

The identity of all the products was established not only by identical m.p., but by the mixed m.p. also, which remained unchanged. The equivalent weight was found by titration against baryta as well as sodium hydroxide. (Found : N, 7.56 ; equiv., 189.5, 190.5. $C_{11}H_{13}O_2N$ requires N, 7.33 per cent. Equiv., 191). The acid crystallised from alcohol in yellow shining leaflets. Its colour deepens at 205°, becoming perfectly brown at 210°. Shrinking starts at 213°, while complete melting takes place at 216°, with great effervescence and colour changing to dark red. It is soluble in absolute alcohol, a little less in acetone, chloroform and benzene, and is almost insoluble in water and ether. It readily decolourises bromine water and Baeyer's reagent in the cold. Its amphoteric character is seen in its easy solubility in alkalis as well as in inorganic acids. With silver nitrate it gives a curdy yellow precipitate of the silver salt.

Attempted preparation of p-*Dimethylaminobenzylidenemalonic Acid.*—Every experment devised for this purpose failed ; in most of them almost the whole of the aldehyde was recovered unchanged. The experiments composed in heating on the water-bath alone the aldehyde and the malonic acid in molecular proportions, at different temperatures of water-bath, heating with strong and glacial acetic acid, with absolute alcohol, with acetic anhydride, and in an inert atmosphere (nitrogen). In cases where the recovered aldehyde was less, resinificatation had already taken place.

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CHEMISTRY OF PROTEOLYSIS

BY SUDHINDRA NATH SEN

Explanations have been put forward on the basis of the dipole moments of C—H, C—C, N—H bonds for the enzymatic breakdown of protein molecules.

The observed fact that proteolysis is favoured in the vicinity of an aromatic ring, is suggested to be due to the property of this group to induce polarity in the neighbouring carbon atom. Conditions that would fail to induce polarity, would retard the process of hydrolysis.

The function of enzyme is to form an activated complex with protein and then to ionise the —CONH-linkage by induced polarity. This complex reacts with H^+ and OH^- until equilibrium is established. The lowering of energy of activation in the process of proteolysis is accounted for by the work done in bringing the (OH^-) within the range of action of the peptide linkage against the potential of the field.

Presence of amino-acids of opposite rotatory power to that met with in nature inhibits the action of pepsin. This is due to a change in the planer position of different groups which probably fails to induce polarity at —CONH— linkage. The effect of steric hindrance appears to be energetic rather than geometrical in nature.

Enzymes are a group of organic substances of highly specific nature whose functions are to direct chemical reactions in particular directions. It is now recognised that most of them are complex systems made up of a number of components of which the protein moiety determines the specificity of the enzyme. Enzymes do not and cannot influence the equilibrium point of any reaction. They only serve to decrease the time to reach such a state. Thus their function is to reduce the energy of activation for the particular process in which they are acting. The velocity and temperature quotients are specific for a particular enzyme and substrate, but are different for various proteins acted upon by the same enzyme or for a particular protein treated with different enzymes. Lineweaver (*J. Amer. Chem. Soc.*, 1939, **61**, 403) has shown that enzymic reactions have a lower temperature coefficient than the corresponding non-enzymatic reactions. In the process

of hydrolysis of protein by enzymes, the sum total effect is the addition of water molecules to the protein with the formation of lower breakdown products. The nature and the mode of the reactions and the part the enzymes play are not fully known. Northrop (*J. Gen. Physiol.*, 1919-20, **2**, 595 ; *ibid.*, 1922, **5, 263**) suggested that the ionisation of the protein molecule is an essential characteristic precedent to protein hydrolysis. But the ionisation of a big multipolar molecule, such as a protein, is not well understood unless the site and the nature of ionisation that would lead to hydrolysis, are made clear. In dealing with polar reactions, such as protein hydrolysis, the polarisability of the molecules, and the electrostatic nature of the dipole moments of the co-valent bonds present in it, must be considered, as these play a significant part in predisposing the molecule to act in a particular way. It is intended to discuss in this paper the mechanism of proteolysis in the light of modern electronic conception of organic chemistry.

With the exception of Barendrecht (*Biochem. Z.*, 1924, **151,** 363) who supported a radiation theory of enzyme action, almost all authors have postulated an union of enzyme and substrate. Some have favoured the adsorbtion theory (Willstätter and Waldschmidt-Leitz, *Z. physiol. Chem.*, 1923, **125,** 132 ; Northrop, *J. Gen. Physiol.*, 1919, **2, 113,** and others), whereas some have postulated a chemical union between enzyme and substrate (Michaelis and Menton, *Biochem. Z.*, 1913, **49,** 333 ; Stearn, *Ergebn. der. Enzymforschung,* 1938, **7,** 1 ; *J. Chem. Phys.*, 1939, **7,** 970). Tide of evidence is, however, in favour of a chemical union. Since the ultimate product of hydrolysis is not a compound of enzyme and protein, the protein-enzyme complex, after its formation and specific activation, must dissociate itself from enzyme and breakdown products of protein. Two cases may arise here: (*i*) The enzyme may be more strongly bound to the reactant than to the activated complex. Here the release of enzyme will cause an increase in entropy. (*ii*) The enzyme is more strongly bound to the activated complex and the process of separation will involve a decrease in the entropy of the system. Stearn (*loc. cit.*, 1938) found that in most cases the entropy of the protein-enzyme system decreases. This goes to establish an union between enzyme and substrate and this complex molecule, which is still a protein, in turn becomes activated. The activation of a multipolar molecule like protein must be followed by the development of polarity within the molecule. This increase in polarity may be further augmented by the proximity of the polar molecules of the enzyme in the complex. The sum total effect of augmentation may rise to such an extent as to give an ionised molecule instead of merely a molecule of increased polarity. If the energy content of a polyatomic molecule be so increased as to be capable of reactivity, which otherwise it does not possess, it may be assumed that the molecule has passed through a constitutional change. This change is expressed by a modification of the valency formula conventionally assigned to its unexcited form. The usual assumption with respect to activation is that of opening the double bonds. This is preferred because the energy increase attributed to this transformation explains the energy of activation (*cf.* Staudinger, *Ber.*, 1926, **59**, 3035 ; Flory, *J. Amer. Chem. Soc.*, 1937, **59**, 241). The dipole moments (in 10^{-18} e.s.u.) of the principal linkages that occur in any peptide chain are $C-H$, 0.2 ; $N-H$, 1.5 ; $C-C$, 0 ; $C=O$, 2.5. Since ionisation will only take place at the site of maximum polarity, the peptide linkage ($-CONH-$) becomes the site of ionisation and maximum reactivity. Since the activation of water molecule is an essential feature

in any enzymatic hydrolysis, as shown by Battelli and Stern (*C.R.A.C.Sc.*, Geneva, 1922, **37**, 65), the mechanism of proteolysis, subsquent to activations may be taken as the addition of polar groups of H^+ and OH' to the ionised protein molecule, which then breaks into products of lower molecular weight. Thus the whole process may be represented in short as follows :—

$$-CH_2-\overset{\overset{O}{\parallel}}{C}-\overset{\overset{H}{|}}{N}-CH_2- \underset{\longleftarrow}{\overset{\longrightarrow}{}} -CH_2-\overset{\overset{O^-}{|}}{\underset{\underset{OH}{|}}{C^+}} \underset{}{\overset{}{\vert}} \overset{\overset{+H}{|}}{\underset{\underset{H}{|}}{N}}-CH_2 \underset{\longleftarrow}{\overset{\longrightarrow}{}} -CH_2-\overset{\overset{O}{\parallel}}{\underset{\underset{OH}{|}}{C}} + H_2NCH_2-$$

$$OH^-\ H^+$$
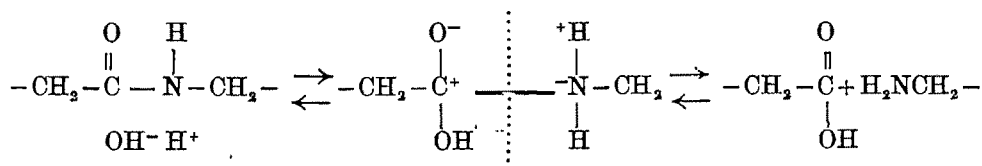
Addition of H^+ incurs no difficulty. It differs from all other ions in having no electron either in nucleus or inside and in presence of other ions or molecules there is nothing to prevent it from penetrating the electron-shell of the first atom that it meets until repelled by the positive charge of the nucleus. It will remain there provided there are two unshared electrons in whose orbit it can wrap itself. The addition of OH' is, however, not so easy. Although it is facilitated by electron attracting groups created in the molecule by way of activation, work has to be done in bringing (OH') group through the potential of the field. The lowering of energy of activation in a process by the foreign molecule of enzyme is entirely accounted for by the work done in bringing the OH' against the potential of the field. Thus the conditions that are to be initiated in the substance before the reaction proceeds are :—

(*i*) ionisation of the reagents, (*ii*) inoisation of the reactant or alternatively the ionisation at the double bond, (*iii*) formation of co-valent molecule and then (*iv*) conversion of co-valency into electro-valency to neutralise all electrical charges.

All these reactions need not, however, proceed independently and consecutively but may be compiled together so that the energy liberated by one of the operations is available to meet the requirements of another. These conditions are created and requirements are met with by the formation of protein-enzyme complex.

Since a proteinase attacks the peptide linkage, it is reasonable to suppose that it will be able to break the protein molecule completely into amino-acids, but experimental evidences are against this conclusion. Proteinases can hydrolyse protein only to a limited extent. This can be explained as follows. So long as the sites of activation reside in separate portions of the molecule with increased length of the interposed chain, they become independent of each other so that they may be regarded as disconnected monovalent radicals. Thus we find the specificity of different enzymes—proteinase, peptidase, etc.—though practically of similar nature, depends strictly on the length of the chain they attack.

It is now known that small chemical change in some of the groups of the side-chain or a small alteration in the spatial configuration of the protein might be enough to destroy the enzyme activity. These points are now discussed in detail.

Proteinases are particularly sensitive to the presence and the special nature of side chain

(Bergmann *et al.*, *J. Biol. Chem.*, 1936, **114**, 717 ; 1937, **118**, 405 ; Fruton and Bergmann, *ibid.*, 1937, **118**, 627). It has been shown that for pepsin hydrolysis, if the substrate contains a free COOH group close to the peptide bond, hydrolysis becomes very rapid. Substitution of this COOH so as to give an ' amide ' makes the substrate entirely resistant to the pepsin action. The most favourable combination is of glutamic acid with tyrosine. The substitution of tyrosine with phenylalanine has no altered effect, whereas masking of the COOH group of glutamic acid makes it resistant to peptic hydrolysis. Thus the presence of a free amino group in close proximity to a peptide bond makes the substrate unsuitable for pepsin action. Similarly Hofmann and Bergmann (*J. Biol. Chem.*, 1939, **130**, 81) have shown that presence of basic amino or guanidino group, but not of free COOH group, is essential for the action of trypsin. If the free amino group is masked, trypsin has no hydrolysing effect. This faculty of differentiation on the part of proteinase can be explained by a combination of the enzyme and the substrate through the different specific groups.

Experimental evidences show that the breakdown of a peptide linkage is much favoured in the vicinity of an aromatic nucleus (Fruton and Bergmann, *J. Biol. Chem.*, 1939, **127**, 627 ; Northrop *et al.*, *Ergeb. der. Enzymforschung*, 1932, **1**, 302). This preferential hydrolysis may be accounted for by the fact that the phenyl group attached to the carbon atom of the peptide linkage is able to induce polarity in the molecule (*cf.* Burton and Ingold, *J. Chem. Soc.*, 1928, 904 ; *Proc. Leeds Phil. Soc.*, 1929, **1**, 421). This increased polarity in the molecule makes it more susceptible to ionic reaction leading to hydrolysis. Direct experimental proof of this type of change in the molecule is as difficult to find as it is to disprove it. The proposed mechanism would, however, lose its significance if it were proved to occur in molecules where polarity does not exist or in the neighbourhood of two polar groups, where the polar effect due to one radical may be taken to be neutralised by the presence of other radical. Experimental evidences show that hydrolysis is greatly retarded in the presence of two tyrosine radicals just on the opposite sides of —CONH— as in the case of *l*-tyrosyl-*l*-tyrosine by pepsin (Fruton and Bergmann, *loc. cit.*). Similarly substitution of glutamic acid by glycine in *l*-glutamyl-*l*-tyrosine, retards hydrolysis.

Proteolytic enzymes are particularly sensitive to one or other optical isomers of amino-acids taking part in the peptide formation. The action of pepsin stops if the peptide linkage contains an unusual amino-acid *i.e.*, amino-acid with opposite optical rotatory power to that met with in nature (Hugonnerq and Loiseleur, *Bull. soc. chem. Biol.*, 1925, **7**, 955 ; Iwai, *Z. physiol. Chem.*, 1924, **136**, 173 ; Fruton and Bergmann, *J. Biol. Chem.*, 1939, **127**, 627). Change in optical rotation is due to a change in the geometrical configuration of the molecule and the failure of pepsin to hydrolyse a peptide linkage containing an unnatural amino-acid, which it otherwise hydrolyses in presence of the natural isomer, may be attributed to a change in the specific configuration of the molecule concerned. An attempt is being made in the following lines to show how the change in configuration affects hydrolysis. The absolute velocity of a chemical reaction is given by the number of molecules reacting per second, which in turn, equals the number of molecules colliding per second multiplied by the chance, that the colliding particles have sufficient energy to react. In a number of instances and specially in enzymic reactions, it

has been found that the reaction values found from the velocity constant of the reaction $(K=PZe^{-E/RT})$ and that obtained from the energy of activation are not of the same order of magnitude. The agreement of two values means that every collision of the activated molecules is fruitful in producing a chemical reaction. Where two methods yield divergent results, steric factors are considered to be responsible for the difference. Stern (*loc. cit.*) found thermodynamically while dealing with enzymic reactions, that enzyme protein complex formation does take place, but hydrolysis is not so great as would be expected. In most cases the entropy of activation of the reaction was considerably more negative than that of the same reaction catalysed by acids. This means that the increase in the reaction rate brought about by the enzyme is not so great as might be expected from the decrease of activation energy.

To visualise the whole picture, a mathematical interpretation is given below. If n molecules of enzyme, by their united effect, reduce the energy of activation from an original value of E_0 to E, each contributing a reducing effect e, then $\Delta E = ne$. Now this will take place only when all the reactive groups of enzyme and protein are properly placed, but the chances that they will do so will be proportional to p^n where p is less than unity. Thus the probability of the reaction, from the relation $K=PZe^{-E/RT}$, although increased by $e^{ne/RT}$ is also reduced by p^n. Therefore from these relations (a) $\Delta E = ne$ and (b) $p/p_0 = p^n$, after eliminating n, we find $\Delta E \propto \Delta \log P$. Since Z does not vary from its average value appreciably, the variation in the reaction velocity is dependent either on E or on P or on both. A systematic variation in the energy of activation E has been observed with change in the field intensity F and this again depends on the position of different groups in the molecule (Ingold and Nathan, *J. Chem. Soc.*, 1936, 222 ; Hinshelwood and Legard, *ibid.*, 1935, 587). It is also known that the probability factor P depends on the position of different groups in the molecule.

All these go to show that there is a factor which might be a stringent condition of neutral orientation of the substrate and enzyme molecules which interferes with the reaction. It follows therefore that though the polar groups in the molecule primarily dominate the rate of hydrolysis, steric hindrance also plays a great part so that all the collisions are not fruitful in producing a reaction. Hinshelwood and Legard (*loc. cit.*) have shown that reaction velocity is slow not because P is small but because E is not large and in a system where E is large P is always large. Thus a system may become reactive when a large amount of energy is supplied to it, and the factor which normally renders some collisions ineffective in the initial system would have then very little effect. According to the present day conception, the addition of energy to a molecule results in an increase in the vibrational and translational motions of electrons. It is the four pairs of electrons about a carbon atom which are responsible for the direction of valency to the apices of tetrahedron. They are thus also responsible for the optical activity of a particular carbon atom. It is, however, possible that by addition of sufficient quanta of energy, the sphere of action of these electrons can be controlled. This will lead to a high degree of activation which will cause such a high degree of polarisation that the transitional probability factor will tend to approach unity and every collision will lead to a reactive product. Thus steric hindrance which creates the probability factor, appears to be energetic rather than geometrical in nature.

STUDIES ON BASIC SULPHATES OF BIVALENT METALS (Cd, Cu, Zn). PART I. CADMIUM

By Barun Chandra Haldar

The author has studied the basic sulphates of cadmium by thermometric titrations of cadmium sulphate solution with caustic soda solution and *vice versa*. Basic sulphates $CdSO_4.3CdO$ and $CdSO_4.CdO$ have been found to exist.

Literatures on basic sulphates of cadmium show that there are two definite compounds, namely, $CdSO_4.CdO.H_2O$ (Grutzner, *Arch. Pharm.*, 1898, **236**, 380) and $CdSO_4.2CdO.H_2O$ (Stromeyer, *Schw. J.*, 1818, **22**, 367 ; Kuhn, *Arch. Pharm.*, 1847, **100**, 286 ; Hebermann, *Monatsh*, 1884, **5**, 448). Pickering has reported the existence of another basic salt of the formula $CdSO_4.3CdO$ (*J. Chem. Soc.*, 1886, **91**, 1907). He has observed that on addition of a small quantity of soda to Cd-sulphate solution in presence of phenolphthalein, only the precipitate is coloured pink and the solution shows alkaline reaction only when alkali amounting to 0.731 equivalent has been added. This observation has been explained by him as due to the formation of the basic sulphate $CdSO_4.3CdO$, although he has admitted that 0.731 equivalent of alkali does not correspond exactly with the compound $CdSO_4.3CdO$. In order to obtain definite indications of the formation of different basic sulphates of cadmium, thermometric titrations of cadmium sulphate with caustic soda solution has been employed here.

Experimental

The thermometric titration arrangement consists of a Dewar flask placed inside another Dewar flask. The solution to be titrated is taken inside the inner flask. The mouth of the inner vessel is closed by means of a cork provided with three bores. Through one bore passes a Beckmann thermometer reading to the 1/100th of a degree accurately, through the second bore passes a glass stirrer worked mechanically and through the third bore passes the tip of the burette. The burette is jacketed with a glass jacket containing water. The stop-cock of the burette is worked with a rubber-tube. The mouth of the outer Dewar vessel is also closed by means of a three-bored asbestos sheet. The titre is added from the burette to the titrant in the inner flask and changes in the temperature are noted on the Beckmann thermometer after definite intervals of time. The differences in temperature are then plotted against the volume of titre in c.c. added from the burette and the graphs are obtained. The reagents used were of 'Analar' quality. Standard solutions of Cd sulphate were prepared by direct weighing. Caustic soda solutions were prepared by standardising with potassium bi-iodate using Wesslow as an indicator.

TABLE I

$CdSO_4$ soln.$=0.4954M$. NaOH soln.$=2.477M$. $CdSO_4$ soln. taken$=40$ c.c. (Fig. 1).

NaOH added.	Temp.	Rise in temp.	Total rise in temp.	NaOH added.	Temp.	Rise in temp.	Total rise in temp.
0 c.c.	3.900°	0.000°	0.000°	11 c.c.	2.600°	0.035°	1.300°
1	3.790	0.110	0.110	12	2.570	0.030	1.330
2	3.640	0.150	0.260	13	2.560	0.010	1.340
3	3.490	0.150	0.410	14	2.560	0.000	1.340
4	3.340	0.150	0.560	16	2.560	0.000	1.340
5	3.190	0.150	0.710	18	2.560	0.000	1.340
6	3.040	0.150	0.860	20	2.560	0.000	1.340
7	2.890	0.150	1.010	22	2.560	0.000	1.340
8	2.780	0.110	1.120	24	2.560	0.000	1.340
9	2.700	0.080	1.200				
10	2.635	0.065	1.265				

TABLE II

$CdSO_4$ soln.$=0.19992M$. NaOH soln.$=0.9996M$. $CdSO_4$ soln taken$=40$ c.c. (Fig. 2).

NaOH added.	Temp.	Rise in temp.	Total rise in temp.	NaOH added.	Temp.	Rise in temp.	Total rise in temp.
				9.0 c.c.	2.360°	0.020°	0.590°
0 c.c.	2.950°	0.000°	0.000°	9.5	2.335	0.025	0.615
1	2.910	0.040	0.040	10.0	2.310	0.025	0.640
2	2.835	0.075	0.115	10.5	2.285	0.025	0.665
3	2.760	0.075	0.190	11.0	2.260	0.025	0.690
4	2.685	0.075	0.265	12.0	2.210	0.050	0.740
5	2.610	0.075	0.340	13.0	2.190	0.020	0.760
6	2.540	0.070	0.410	14.0	2.190	0.000	0.760
7	2.470	0.070	0.480	16.0	2.190	0.000	0.760
8	2.405	0.065	0.545	18.0	2.190	0.000	0.760
8.5	2.380	0.025	0.570	20.0	2.190	0.000	0.760

TABLE III

CdSO$_4$ soln.$=0.09996M$.   NaOH soln.$=0.9996M$.   CdSO$_4$ soln. taken$=40$ c.c. (Fig. 3).

NaOH added.	Temp.	Rise in temp.	Total rise in temp.	NaOH added.	Temp.	Rise in temp.	Total rise in temp.
0.0 c.c.	3.570°	0.000°	0.000°	5.5 c.c.	3.220°	0.030°	0.350°
1.0	3.530	0.040	0.040	6.0	3.195	0.025	0.375
2.0	3.460	0.070	0.110	7.0	3.180	0.015	0.390
3.0	3.390	0.070	0.180	8.0	3.165	0.015	0.405
4.0	3.320	0.070	0.250	9.0	3.155	0.010	0.415
4.5	3.285	0.035	0.285				
5.0	3.250	0.035	0.320	10.0	3.145	0.010	0.425

TABLE IV

CdSO$_4$ soln.$=0.05M$.   NaOH soln.$=0.4M$.   CdSO$_4$ soln. taken$=40$ c.c. (Fig. 4).

NaOH added.	Temp.	Rise in temp.	Total rise in temp.	NaOH added.	Temp.	Rise in temp.	Total rise in temp.
0.0 c.c.	4.110°	0.000°	0.000°	6.5 c.c.	3.855°	0.020°	0.255°
1.0	4.080	0.030	0.030	7.0	3.835	0.020	0.275
2.0	4.035	0.045	0.075	7.5	3.820	0.015	0.290
3.0	3.995	0.040	0.115	8.0	3.810	0.010	0.300
4.0	3.955	0.040	0.155	9.0	3.800	0.010	0.310
5.0	3.915	0.040	0.195	10.0	3.790	0.010	0.320
5.5	3.895	0.020	0.215	11.0	3.780	0.010	0.330
6.0	3.875	0.020	0.235	12.0	3.770	0.010	0.340

TABLE V

CdSO$_4$ soln.$=0.025M$.   NaOH soln.$=0.39756M$.   CdSO$_4$ soln. taken$=40$ c.c. (Fig. 5).

NaOH added.	Temp.	Rise in temp.	Total rise in temp.	NaOH added.	Temp.	Rise in temp.	Total rise in temp.
0 c.c.	4.515°	0.000°	0.000	5.0 c.c.	4.360°	0.010°	0.150°
1.0	4.485	0.030	0.030	6.0	4.350	0.010	0.160
2.0	4.445	0.040	0.070	7.0	4.340	0.010	0.170
2.5	4.425	0.020	0.090	8.0	4.330	0.010	0.180
3.0	4.405	0.020	0.110	9.0	4.320	0.010	0.190
3.5	4.390	0.015	0.125	10.0	4.310	0.010	0.200
4.0	4.375	0.015	0.140				

TABLE VI

CdSO$_4$ soln.$=0.6115M$.   NaOH soln.$=0.2959M$.   NaOH$_4$ soln. taken$=40$ c.c. (Fig. 6).

CdSO$_4$ added.	Temp.	Rise in temp.	Total rise in temp.	CdSO$_4$ added.	Temp.	Rise in temp.	Total rise in temp.
0 c.c.	4.200°	0.000°	0.000	9 c.c.	3.330°	0.090°	0.880°
1	4.115	0.095	0.095	10	3.280	0.050	0.930
2	4.010	0.105	0.200	11	3.280	0.000	0.930
3	3.910	0.100	0.300	12	3.280	0.000	0.930
4	3.810	0.100	0.400	13	3.270	0.010	0.940
5	3.710	0.100	0.500	14	3.250	0.020	0.960
6	3.610	0.100	0.600	15	3.230	0.020	0.980
7	3.520	0.090	0.690	16	3.210	0.020	1.000
8	3.420	0.100	0.790	17	3.190	0.020	1.020

TABLE VII

CdSO$_4$ soln.$=0.2959M$.   NaOH soln.$=0.1598M$.   NaOH$_4$ soln. taken$=40$ c.c. (Fig. 7).

CdSO$_4$ added.	Temp.	Rise in temp.	Total rise in temp.	CdSO$_4$ added.	Temp.	Rise in temp.	Total rise in temp.
0 c.c.	3.420°	0.000°	0.000°	12 c.c.	3.040°	0.010°	0.380°
1	3.385	0.035	0.035	13	3.040	0.000	0.380
2	3.345	0.040	0.075	14	3.040	0.000	0.380
3	3.320	0.025	0.100	15	3.030	0.010	0.390
4	3.285	0.035	0.135	16	3.015	0.015	0.405
5	3.250	0.035	0.170	17	3.000	0.015	0.420
6	3.215	0.035	0.205	18	2.990	0.010	0.430
7	3.185	0.030	0.235	19	2.980	0.010	0.440
8	3.150	0.035	0.270	20	2.970	0.010	0.450
9	3.115	0.035	0.305	22	2.930	0.040	0.490
10	3.080	0.035	0.340	24	2.920	0.010	0.500
11	3.050	0.030	0.370	26	2.900	0.020	0.520

DISCUSSION

It is evident from the Figs. 1 to 5 that the basic sulphate CdSO$_4$.3CdO is precipitated by the addition of alkali to cadmium sulphate solutions of strength 0.025M to 0.4954M. But at concentrations 0.1999M and 0.495M of Cd sulphate, the basic sulphate CdSO$_4$.CdO is first formed which with excess of caustic soda solution is transformed into CdSO$_4$.3CdO. It is peculiar that cadmium hydroxide is not precipitated even when

FIG. 1

NaOH soln. $= 2·477M$
CdSO$_4$ soln. $= 0·4954M$, taken 40 c.c.

Alkali added (c.c.)
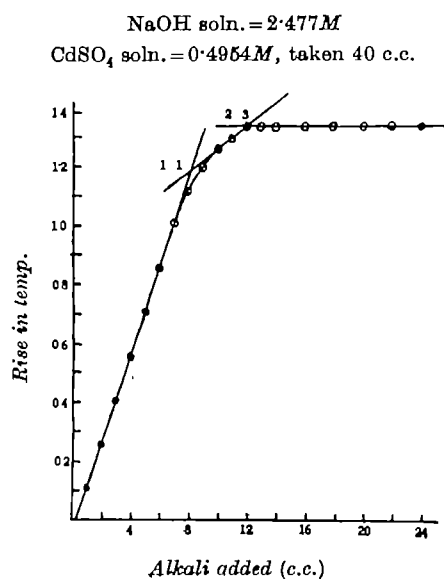
FIG. 2

CdSO$_4$ soln. $= 0.19992M$ taken 40 c.c.,
NaOH soln. $= 0·9996M$.

Alkali added (c.c.)
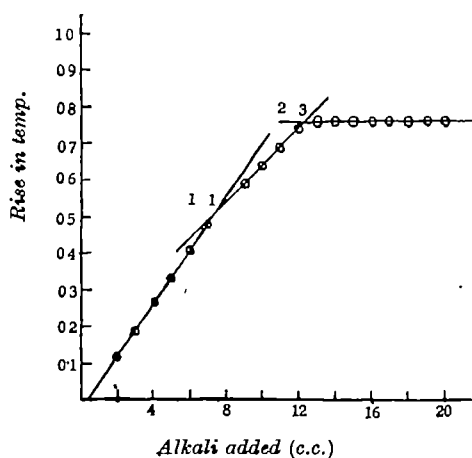
Fig. 3

NaOH soln. $= 0\cdot9996M$.

CdSO$_4$ soln. $= 0\cdot09996M$, taken 40 c.c.
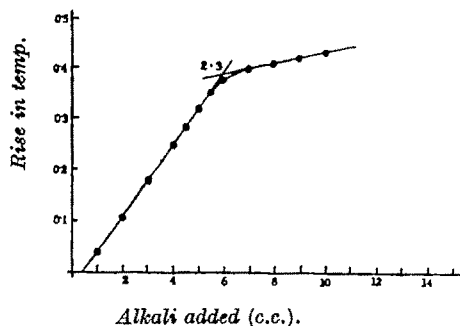
Fig. 4

NaOH soln. $= 0\cdot4M$.

CdSO$_4$ soln. $= 0\cdot05M$, taken 40 c.c.
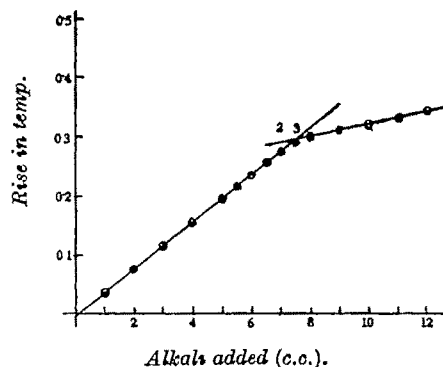
Fig 5

NaOH soln. $= 0\cdot39756M$.

CdSO$_4$ soln. $= 0\cdot025M$, taken 40 c.c.
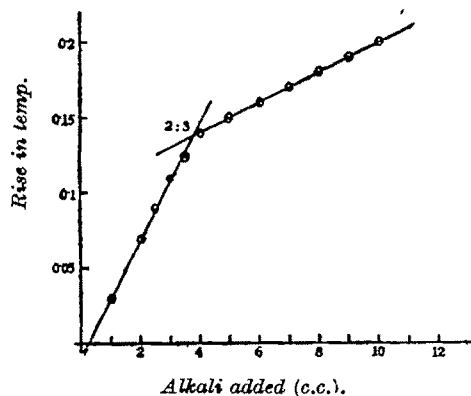
Fig. 6

NaOH soln. $= 0\cdot2959M$.

CdSO$_4$ soln. $= 0\cdot6115M$, taken 40 c.c.
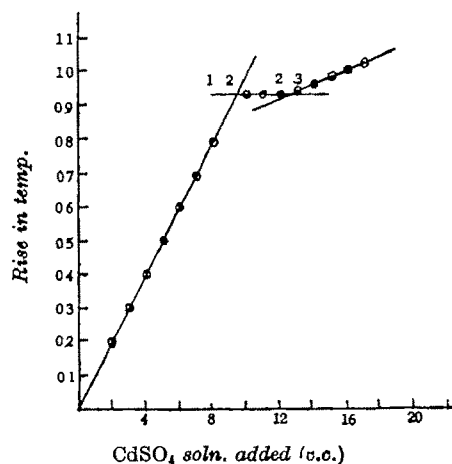
large excess of caustic soda solution has been added to cadmium sulphate solutions. One point, however, is to be noted that although it can be definitely said that the basic sulphate CdSO$_4$.CdO exists, no conclusion can be drawn about the number of water molecules attached to it. Inspite of the fact that various authors have recorded the existence of the basic sulphate CdSO$_4$.2CdO.H$_2$O, no indication of that compound has been observed by this method. The Figs. 6 and 7, i.e., addition of cadmium sulphate solutions to caustic soda solution, show that Cd hydroxide is first precipitated which with more Cd sulphate passes to the basic salt CdSO$_4$.3CdO. Thus it can be concluded that the

6—1607P—4.

FIG. 7
NaOH soln. = 0·1598M.
CdSO$_4$ soln. = 0.2959M, taken 40 c.c.

CdSO$_4$ soln. added (c.c.)
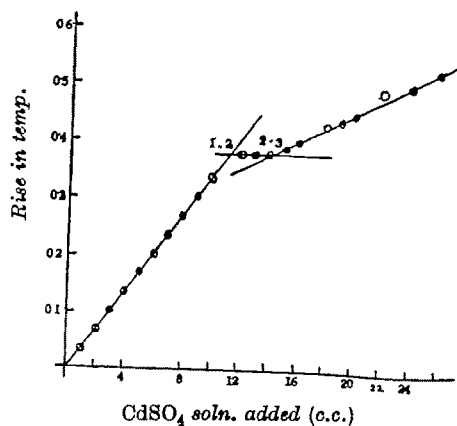
basic salt CdSO$_4$.3CdO is very stable and can be obtained either by the addition of alkali to Cd sulphate solution or *vice versa*. Moreover, the common idea which has found place even in certain text-books that when sodium hydroxide solution is added to Cd sulphate solution, Cd hydroxide is precipitated is not correct.

My best thanks are due Dr. P. B. Sarkar for taking keen interest in the subject and helpful suggestions and for all laboratory facilities.

STUDIES ON BASIC SULPHATES OF BIVALENT METALS (Cd, Cu, Zn)
PART II.   COPPER

By Barun Chandra Haldar

The basic sulphates $CuSO_4.3CuO$ and $CuSO_4.CuO$ have been found to exist.   In presence of excess of caustic soda solution the cuprate $NaCu(OH)_3$ is formed.

Various attempts have been made to study the basic sulphates of copper.   Binder (*Compt. rend.*, 1934, **198**, 653) from phase rule study has obtained the basic sulphate $CuSO_4.3CuO$.   In support of his observation he has stated that X-ray examination also confirms his results.   He has observed further that when copper sulphate is heated to 650° it gives the basic salt $CuSO_4.CuO$ (*Ann. chim.*, 1936, **5**, 337).   Recently conductometric and potentiometric methods have been used by Chretien and Heubel (*Compt. rend.*, 1944, **219**, 363) and Marie-Louise-Brouty (*Compt. rend.*, 1944, **218**, 931) respectively to study the basic sulphate formation of copper.   Both conductometric and potentiometric methods indicate the formation of the basic salt $CuSO_4.3CuO$ in conformity with the previous results.   But the above two methods fail to give any indication of the formation of the basic salt $CuSO_4.CuO$.   Here thermometric titrations of copper sulphate with caustic soda and *vice-versa* have been employed to obtain definite indications about the formation of the different basic sulphates of copper.   If the basic sulphate $CuSO_4.CuO$ is found to exist and appear only in concentrated solutions then the analogy between Cu and Cd with respect to basic sulphate formation will be complete.

Experimental

The thermometric arrangement is the same as that has been described in Part I of this series (*J. Indian Chem. Soc*, 1946, **23**, 157).   Reagents used were of analar quality. Standard solutions of copper sulphate were prepared by direct weighing.   Standard solutions of caustic soda were prepared by standardising with potassium bioidate using Wesslow as an indicator.

Fig. 1
NaOH soln.$=0.4768M$.
$CuSO_4$ soln.$=0.1M$, taken 40 c.c.
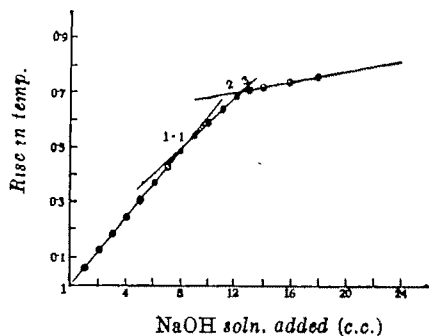
Fig. 2
NaOH soln$=0.4768M$.
$CuSO_4$ soln.$=0.05M$, taken 40 c.c.

NaOH *soln. added* (*c.c.*)

NaOH *soln. added* (*c.c*)
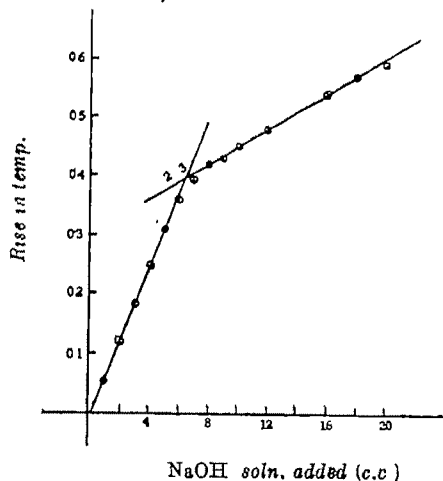
TABLE I

CuSO$_4$ soln.=0.1M.   NaOH soln.=0.4768M.   CuSO$_4$ soln.   taken=40 c.c. (Fig. 1).

NaOH added.	Temp.	Rise in temp.	Total rise in temp.
0 c.c.	2.100°	0.000°	0.000°
1	2.040	0.060	0.060
2	1.970	0.070	0.130
3	1.910	0.060	0.190
4	1.850	0.060	0.250
5	1.790	0.060	0.310
6	1.730	0.060	0.370
7	1.670	0.060	0.430
8	1.610	0.060	0.490
9	1.560	0.050	0.540
10	1.510	0.050	0.590
11	1.460	0.050	0.640
12	1.410	0.050	0.690
13	1.390	0.020	0.710
14	1.380	0.010	0.720
16	1.360	0.020	0.740
18	1.340	0.020	0.760
20	1.310	0.030	0.790

TABLE II

CuSO$_4$ soln.=0.05M.   NaOH soln.=0.4768M.   CuSO$_4$ soln. taken=40 c.c. (Fig. 2).

NaOH added.	Temp.	Rise in temp.	Total rise in temp.
0 c.c.	4.760°	0.000°	0.000°
1	4.705	0.055	0.055
2	4.640	0.065	0.120
3	4.575	0.065	0.185
4	4.510	0.065	0.250
5	4.450	0.060	0.310
6	4.400	0.050	0.360
7	4.365	0.035	0.395
8	4.340	0.025	0.420
9	4.330	0.010	0.430
10	4.310	0.020	0.450
12	4.280	0.030	0.480
14	4.240	0.040	0.520
16	4.220	0.020	0.540
18	4.190	0.030	0.570
20	4.170	0.020	0.590

FIG. 3

NaOH soln.=0.17811M.
CuSO$_4$ soln.=0.04M, taken 40 c.c.
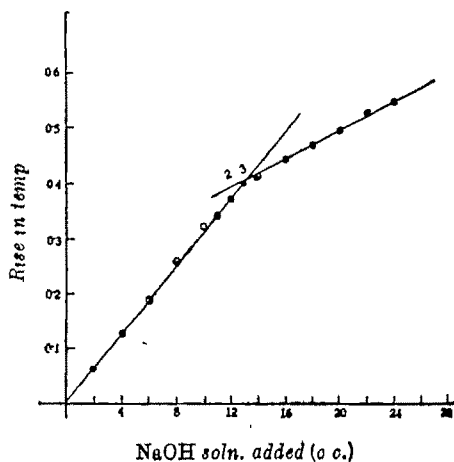
FIG. 4

NaOH soln.=0.1018M.
CuSO$_4$ soln.=0.2M, taken 40 c.c.

NaOH soln. added (c.c.)
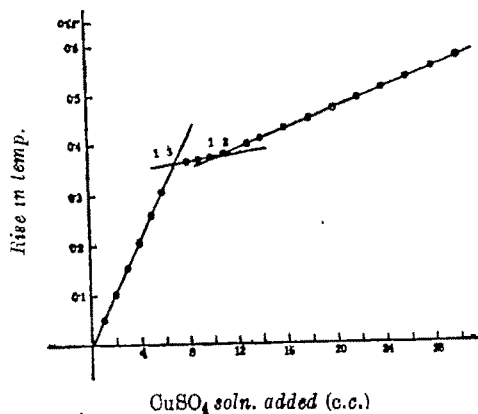
CuSO$_4$ soln. added (c.c.)

TABLE III

CuSO$_4$ soln.$=0.04M$.   NaOH soln.$=0.17811M$.   CuSO$_4$ soln. taken$=40$ c.c. (Fig. 3).

NaOH added.	Temp.	Rise in temp.	Total rise in temp.
0 c.c.	5.320°	0.000°	0.000°
2	5.260	0.060	0.060
4	5.190	0.070	0.130
6	5.130	0.060	0.190
8	5.060	0.070	0.260
10	4.995	0.065	0.325
11	4.975	0.020	0.345
12	4.945	0.030	0.375
13	4.920	0.025	0.400
14	4.905	0.015	0.415
16	4.875	0.030	0.445
18	4.850	0.025	0.470
20	4.820	0.030	0.500
22	4.790	0.030	0.530
24	4.770	0.020	0.550

TABLE IV

CuSO$_4$ soln. $=0.2M$.   NaOH soln.$=0.1018M$.   NaOH soln. taken$=40$ c.c. (Fig. 4).

CuSO$_4$ added.	Temp.	Rise in temp.	Total rise in temp.
0 c.c.	3.010°	0.000°	0.000°
1	2.960	0.050	0.050
2	2.910	0.050	0.100
3	2.855	0.055	0.155
4	2.805	0.050	0.205
5	2.750	0.055	0.260
6	2.705	0.045	0.305
7	2.660	0.045	0.350
8	2.645	0.015	0.365
9	2.640	0.005	0.370
10	2.635	0.005	0.375
11	2.630	0.005	0.380
13	2.610	0.020	0.400
14	2.600	0.010	0.410
16	2.580	0.020	0.430
18	2.560	0.020	0.450
20	2.540	0.020	0.470
22	2.520	0.020	0.490
24	2.500	0.020	0.510
26	2.480	0.020	0.530
28	2.460	0.020	0.550
30	2.440	0.020	0.570

FIG. 5

NaOH soln.$=0$ 125M_a

CuSO$_4$ soln.$=0.25M$. taken 40 c.c.
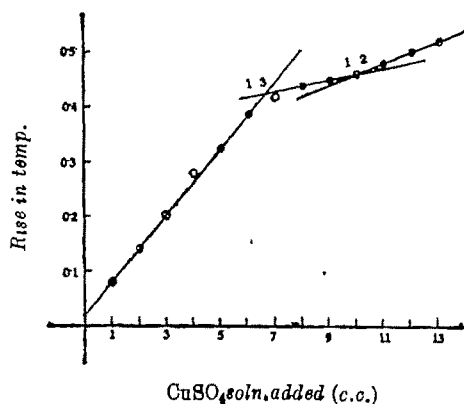
CuSO$_4$ soln. added (c.c.)

TABLE V

CuSO$_4$ soln.=0.25M.   NaOH soln.=0.125M.   NaOH soln. taken=40 c.c. (Fig. 5).

CuSO$_4$ added.	Temp.	Rise in temp.	Total rise in temp.
0 c.c.	3.380°	0.000°	0.000°
1	3.300	0.080	0.080
2	3.240	0.060	0.140
3	3.180	0.060	0.200
4	3.100	0.080	0.280
5	3.050	0.050	0.330
6	2.990	0.060	0.390
7	2.960	0.030	0.420
8	2.940	0.020	0.440
9	2.930	0.010	0.450
10	2.920	0.010	0.460
11	2.900	0.020	0.480
12	2.880.	0.020	0.500
13	2.860	0.020	0.520

DISCUSSION

It appears from Figures 1 to 3 that the basic sulphate CuSO$_4$.3CuO is formed when alkali is added to copper sulphate solution of strength (0.04M to 0.1M). But it is to be observed that only in the case of copper sulphate solution of 0.1M strength, the existence of the basic sulphate CuSO$_4$.CuO has been indicated. Thus it can be concluded that copper like cadmium gives basic sulphate CuSO$_4$.3CuO at concentrations 0.04M to 0.1M. But at concentration 0.1M another basic salt CuSO$_4$.CuO is first formed which with more alkali passess to CuSO$_4$.3CuO. One peculiar fact is that no break in the curve corresponding to Cu(OH)$_2$ is observed. This observation is in conformity with the conductometric results of Chretien and Heubel. The curves in Figs. 4 and 5, $i.e.$, when copper sulphate solution is added to caustic soda solution, show that the cuprate NaCu(OH)$_3$ is first formed which with more copper sulphate passes to Cu(OH)$_2$. But unlike conductometric method, no change of copper hydroxide to CuSO$_4$.3CuO has been observed here. McDowell and Johnston ($J. Amer. Chem. Soc.$, 1936, 58, 2009) have also stated the existence of the cuprate ions Cu(OH)$_3$' and Cu(OH)$_4$'' from solubility data.

Thus it is seen that in basic salt formation copper and cadmium show a very close similarity which may further be extended to other similar bivalent metals.

My best thanks are due to Dr. P. B. Sarkar for his keen interest in the subject and helpful suggestions and for all laboratory facilities.

QUINOLINE DERIVATIVES. PART XII

By S. Banerjee and T. N. Ghosh

Some quinoline-arsonic acid derivatives have been synthesised, which are expected to possess antimalarial properties.

It is sometimes considered desirable to reinforce the specific action of quinine by means of arsenic. The chief value of such a combination is in the treatment of chronic malaria cases, where there is infection of the liver or spleen with accompanying anaemia and cachexia. Dr. A. N. Bose of this laboratory (*private communication*) observed that monkeys infected with the highly virulent strain of *P. Knowlesi* and having repeated relapses even after treatment with 2-chloro-7-methoxy-5 (δ--diethylaminobutyl) amino-acridine (*cf.* Siddons and Bose, *Indian Med. Gaz.*, 1944, **79**, 101) would be permanently cured of the infection by additional injection of an arsenical drug. It was therefore suggested to try for antimalarial activity of quinoline and acridine compounds containing arsenic attached to the nuclei. In view of the observation that the seat of antimalarial action of quinine is in the quinoline nucleus, it has been considered desirable to synthesise some quinoline derivatives having arsenic attached to the quinoline nucleus and to see if they exhibit antimalarial activity (*cf.* Slater, *J. Chem. Soc.*, 1930, 1209 ; Barnett, Gillieson and Kermack, *ibid.*, 1934, 433).

Few quinoline-arsenic acid derivatives are known in literature and they have been prepared by Bart's reaction, which is rather tedious and generally gives very poor yield of the products. Moreover, the necessary amines required for this synthesis by Bart's reaction may not be readily available in stable forms. It has been shown in Part XI (Ghosh and Ray, *J. Indian Chem. Soc.*, 1945, **22**, 257) that the method of Dobner and Miller (*Ber.*, 1881, **14**, 2812) can be successfully applied for the synthesis of quinoline-arsonic acid derivatives. In continuation of this work, 2-phenylquinoline-6-arsonic acid (I) and 2-phenyl-8-hydroxyquinoline-5-arsonic acid (II) have now been synthesised by reacting cinnamic aldehyde with *p*-arsanilic acid and 3-amino-4-hydroxyphenylarsonic acid respectively, according to the method of Dobner and Miller.
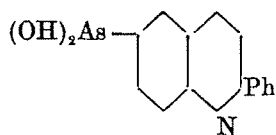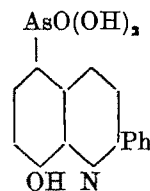
(I)   (II)

It is surmised by pharmacologists that quinquevalent arsonic acids become therapeutically active only on reduction, in the body, to the tervalent state. It might seem natural therefore to reduce the acids first and then to administer the reduced products, provided the latter do not prove toxic to the host. Unfortunately, the difficulty has been to obtain easily soluble and stable derivatives of these tervalent compounds. In view of these

observations, the compound (I) has been reduced with hypophosphorus acid to yield the dihydrochloride of 2 : 2'-diphenyl-6 : 6'-arsenoquinoline (III) which, though found fairly stable on storage, is practically insoluble in water.

(III)
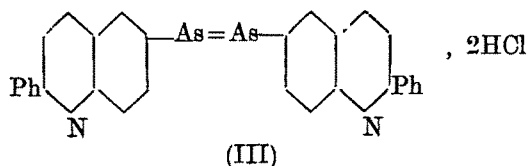
E X P E R I M E N T A L

2-Phenylquinoline-6-arsonic Acid (I).—Commercial concentrated hydrochloric acid (28 c.c.) was poured dropwise into a flask containing well-powdered *p*-arsanilic acid (30 g.), when the hydrochloride of *p*-arsanilic acid was obtained. To this mixture was added dropwise cinnamic aldehyde (20 g.) with stirring, when there was a slight rise in temperature and the mass changed to orange-red. The mixture was then heated on the oil-bath at 105-10° for 3 hours, when a thick, clear solution was obtained. It was next heated at 120-25° for 3 hours and then allowed to stand overnight.

Next day the solution was diluted with a large quantity of water, when some amount of tarry mass was precipitated. The mixture was allowed to stand for sometime and then the supernatant clear solution was decanted. The solution was then carefully neutralised, under cooling, with a cold 20% aqueous caustic soda solution, when a flocculent precipitate was obtained, which on standing became granular. The solid was filtered, washed thoroughly with water and was finally crystallised from a large quantity of alcohol in colourless, crystalline powder (yield 6 g.), which does not melt even at 340° but changes to light brown at about 300°. (Found : N, 4.27 ; As, 22.97. $C_{15}H_{12}O_3NAs$ requires, N, 4.25 ; As, 22.79 per cent). It is practically insoluble in boiling water. It does not contain any diazotisable amino group. A dilute hydrochloric acid solution of this compound gives a brown precipitate with Mayer's reagent.

The yield of the above compound was raised to 10 g., when the reaction was carried out at 115-20° for 6 hours.

2-Phenyl-8-hydroxyquinoline-5-arsonic Acid (II).—In this reaction 3-amino-4-hydroxyphenylarsonic acid (25 g.), commercial concentrated hydrochloric acid (20 c.c.) and cinnamic aldehyde (20 g.) were used and the mixture was heated at 115-20° for 6 hours. Subsequent procedure was the same as described above. After neutralisation with 10% aqueous caustic soda solution, no precipitate was, however, obtained. The clear solution was then saturated with pure sodium chloride and allowed to stand overnight. Next day a precipitate was obtained, which was filtered, washed thoroughly with water and finally crystallised from boiling water in brownish crystalline powder (yield 5 g.). It was dried *in vacuo* at 120° and then analysed. (Found : As, 21.29. $C_{15}H_{12}O_4NAs$ requires As, 21.73 per cent). It does not melt even at 330° and does not contain any diazotisable amino group. Its aqueous solution gives a deep red colouration with ferric chloride.

2 : 2'-Diphenyl-6 : 6'-arsenoquinoline Dihydrochloride (III).—The compound (I, 5 g.),

in 50 c.c. of water and 10 c.c. of concentrated hydrochloric acid, was reduced with 35% hypophosphorus acid (33 g.) and 3 c.c. of 1% aqueous solution of potassium iodide, by warming the soution on the water-bath and passing in a stream of carbon dioxide. Within 15 minutes the reduced product separated out as a yellow solid, which was cooled, filtered and washed with dilute hydrochloric acid, water and finally with alcohol; yield 3 g. It is a fine, yellow powder, practically insoluble in boiling water, alcohol or concentrated hydrochloric acid. It is soluble in concentrated sulphuric acid. On heating, it turns brown at 150°, becomes viscous at 220-22° and decomposes at 250°. It was dried at 100° *in vacuo* and then analysed. (Found : N, 4.41 ; As, 24.27. $C_{30}H_{20}N_2As_2$. 2HCl requires, N, 4.44 ; As, 23.8 per cent).

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A NOTE ON THE ESTIMATION OF THIOSULPHATE

BY ARUN K. DEY AND A. K. BHATTACHARYYA

Fogh (*Compt. rend.*, 1890, 110, 709 ; *Ann. chim. phys.*, 1890, *vi*, 21, 81) has reported that when silver nitrate is acted upon by sodium thiosulphate, silver thiosulphate is first formed. This product decomposes in presence of water to form silver sulphide as observed by Girard (*Ann. Chem. Anal. App.*, 1900, 5, 56). The reactions may be represented as follows :—

$$2AgNO_3 + Na_2S_2O_4 = Ag_2S_2O_3 + 2NaNO_3$$
$$Ag_2S_2O_3 + H_2O = Ag_2S + H_2SO_4$$
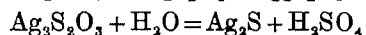
These facts have been utilised by us for the quantitative determination of sulphur in a solution of thiosulphate.

A solution of thiosulphate was prepared, and standardised with the aid of standard sodium arsenite and iodine solutions. To a measured volume of the thiosulphate solution was added drop by drop with constant stirring a solution of silver nitrate, till complete precipitation occurred. The colour of the precipitate was at first white, which soon changed to brick-red and finally to deep brown, probably due to the change of silver thiosulphate to silver sulphide. This precipitate was filtered in a Gooch crucible, washed thoroughly with water and the filtrate received in a beaker. The Gooch crucible was heated in an air-oven at 120° to a constant weight. The filtrate was concentrated to about 200 c.c., acidified slightly with nitric acid, boiled and a boiling solution of barium nitrate added drop by drop till barium sulphate precipitated completely. This was allowed to stand on a water-bath till the precipitate settled and the solution poured through a filter, the precipitate washed with hot water, filtered, dried, ignited and estimated as usual. The amount of sulphur contained in the precipitated silver sulphide and barium sulphate was calculated and thus the amount of total sulphur present in the solution known. It was found that the results obtained were fairly satisfactory, and the values lay within permissible error.

We thank Professor K. P. Chatterji for his kind interest in this work.

MAGNETO-CHEMICAL STUDIES IN VALENCY AND MOLECULAR CONSTITUTION. PART II. MAGNETIC MOMENT AND MOLECULAR CONFIGURATION OF SOME TRIPLE NITRITES AND METALLIC CYANIDES CONTAINING ELEMENTS OF THE FIRST TRANSITIONAL SERIES

By Priyadaranjan Ráy and Harinarayan Sahu

A number of triple nitrites containing bivalent Co, Ni, Cu and Fe as the central atom and a double nitrite of bivalent nickel have been magneto-chemically examined. From a consideration of their magnetic moment values it has been concluded that almost all of them belong to the penetration type of co-ordination complexes with fairly strong co-valent bonds.

Magnetic susceptibilities of both hydrated and anhydrous nickel cyanides, prepared from extremely pure ingredients, have also been measured. The observed moment values have been found to agree with those given by some of the previous workers. Following Pauling an explanation has been advanced for the values thus obtained which are much lower than that of the nickelous ion in its simple salts, and a configuration for the anhydrous cyanide has been suggested on the basis of planar dsp^2 bonds together with a few ionic bonds in the form of polymerised molecules.

Cobaltous cyanide, both in the hydrated and anhydrous state, have also been found to behave magnetically like the nickel cyanide, and in the anhydrous state consists like the latter of polymerised molecules with the cobaltous atom in both planar dsp^2 bonds and ionic bonds.

A number of triple nitrites containing bivalent iron, cobalt, nickel and copper has long been described in the literature. The strong and striking colour of these seems to suggest that they are true penetration complexes and are not mere molecular compounds or triple salts. Their instability, due to more or less rapid hydrolysis in water, obviously precludes their study by the usual physico-chemical methods generally applicable to solutions. Under the circumstances, the magnetic method of investigation at once suggests itself as a very convenient and ready means of determining the nature of the chemical bond between the transitional metal atom and the nitrito groups, and thus deciding the configuration of the molecule as a whole. The present work was undertaken with this end in view.

Magnetic measurements have also been made on the hydrated and anhydrous cyanides of bivalent nickel and cobalt ; and a discussion of the results has led to an insight into their molecular configuration and the nature of the metal-cyanogen bond.

EXPERIMENTAL

Preparation of the Materials.

1. *Potassium Calcium Cobalto-nitrite.*—A solution of 2.4 g. of nickel-free cobalt chloride (Scherring-Kahlbaum) dissolved in the least amount of cold water was added to that of calcium chloride, prepared from 3 g. of calcium carbonate (guaranteed reagent, Scherring-Kahlbaum), and the mixture was thoroughly cooled. A neutral solution of potassium nitrite was prepared by dissolving 14 g. of the pure salt (Scherring-Kahlbaum) in 25 c.c. of cold water and carefully neutralising the solution to phenolphthalein. This was cooled in ice and the two solutions were then mixed together in a beaker surrounded with ice and the mixture was vigorously stirred for 15 minutes. A dirty yellowish green product separated from the mixture. This was filtered by suction in a Buchner funnel and was

washed thrice with ice-cold water, then with cold 50% dilute alcohol and finally with absolute alcohol. The product was dried in air to a constant weight (*cf.* Cuttica and Paoletti, *Gazzetta*, 1922, 52, 276). {Found : Co, 13.07, 12.98 ; Ca, 7.92, 7.90 ; K, 18.43, 18.70 ; NO_2, 60.90, 60.81. $K_2Ca[Co(NO_2)_6]$ requires Co, 13.03 ; Ca, 8.83 ; K, 17.22 ; NO_2, 60.90 per cent}.

The results show that the proportion of K and Ca does not agree with the theoretical value as given by Cuttica and Paoletti (*loc. cit.*). Several samples were prepared by varying the proportion between the constituents. But all attempts to prepare the compound of the given composition led always to variable values for K and Ca, though the sum of their equivalent proportions remained unchanged, being equal to 4 in all cases, as demanded by the principle of electrical neutrality for the molecule as a whole. Hence, an isomorphous replacement obviously occurs under all circumstances between K^+ and Ca^{++} ions which do not differ considerably either in their size or mass.

2. *Potassium Lead Cobalto-nitrite.*—Its preparation resembles that of the previously described calcium salt, calcium chloride being replaced by lead nitrate. The substance formed a dark black, micro-crystalline precipitate. This was dried in a vacuum desiccator to a constant weight (Cuttica and Paoletti, *loc. cit.*). {Found : Co, 9.49, 9.50 ; Pb, 33.43, 33.41 ; K, 12.70, 12.71 ; NO_2, 44.30, 44.40. $K_2Pb[Co(NO_2)_6]$ requires Co, 9.52 ; Pb, 33.40 ; K, 12.60 ; NO_2, 44.50 per cent}.

3. *Potassium calcium nickelo-nitrite* was prepared in the same way as the corresponding cobalt salt described above, cobalt-free nickel nitrate replacing the cobalt nitrate. The substance, which separated as a light yellow micro-crystalline precipitate, was washed with ice-cold water, 30% acetone solution and with pure acetone in succession. It was dried in air (*cf.* Erdmann, *Z. anal. Chem.*, 1864, 3, 161 ; Mousseron and Carriteau, *J. Pharm. Chem.*, 1932, 16, 282). {Found : Ca, 7.90 ; K, 15.51 ; Ni, 11.60 ; NO_2, 54.53. $K_2Ca[Ni(NO_2)_6]$ requires Ca, 7.91 ; K, 15.43 ; Ni, 11.58 ; NO_2, 54.44 per cent}.

4. *Potassium nickelo-nitrite* was prepared from cobalt-free nickel nitrate and a neutral solution of potassium nitrite in a manner similar to that adopted for the preparation of the triple salt described above. The orange-red precipitate was washed successively with small quantity of ice-cold water, 30% cold acetone and finally with pure acetone. The substance was dried in air to a constant weight (*cf.* Erdmann and also Mousseron and Carriteau, *loc. cit.*). {Found : K, 31.83 ; Ni, 11.97 ; NO_2, 56.10. $K_4[Ni(NO_2)_6]$ requires K, 31.85 ; Ni, 11.95 ; NO_2, 56 22 per cent}.

5. *Potassium Calcium Cupri-nitrite.*—Chemically pure recrystallised copper chloride (8.5 g.) was dissolved in 25 c.c. of cold aqueous solution of 15 g pure sodium nitrite. There was a slight evolution of heat and of some N_2O_3 with the precipitation of a little basic copper salt. The solution was filtered and treated with a neutral solution (30 c.c.) of calcium chloride prepared from 5 g. of calcium carbonate (Scherring-Kahlbaum, guaranteed reagent), which also contained 20 g. of pure sodium nitrite and 7.4 g. of pure potassium chloride (Merck). The solutions were cooled to 5° before mixing by means of a freezing mixture. On stirring for about ten minutes a crystalline green precipitate separated out and some nitrous fumes were evolved. After cooling thoroughly it was filtered at the pump to remove most of the mother-liquor. The substance was then made into a paste with 85% alcohol, and allowed to settle. The alcohol was then poured out and

the substance was then stirred with a little acetone and transferred to the filter. It was afterwards washed with absolute alcohol and dried to a constant weight in a vacuum desiccator (*cf.* Przibylla, *Z. anorg. Chem.*, 1897, **15**, 419). {Found : Cu, 14.03 ; Ca, 8.75 ; K, 17.0 ; NO_2, 59.44. $K_2Ca[Cu(NO_2)_6]$ requires Cu, 13.90 ; Ca, 8.72 ; K, 17.04 ; NO_2, 60.32 per cent}.

6. *Ammonium Lead Cupri-nitrite* —Copper nitrate (4.8 g.) prepared from electrolytic copper was dissolved in 30 c.c. of a solution containing 6.6 g. of chemically pure lead nitrate (Kahlbaum) in it. The mixture was made neutral to litmus. 3.2 G. of chemically pure ammonium nitrite (Merck) and 16. 5 g. of pure sodium nitrite were dissolved in 30 c.c. of water and this solution was also made neutral to litmus. The solutions were cooled to 8° and filtered. They were then mixed together in a beaker cooled in ice and the mixture was stirred for about 15 minutes. On standing, a black crystalline salt settled down. It was filtered at the pump and washed successively with small quantities of ice-cold water, 30% acetone solution and finally with pure acetone. The product was dried in a vacuum desiccator to a constant weight (Przibylla, *loc. cit.*). {Found : Cu, 11.03 ; Pb, 35.50 ; NH_4, 6.23 ; NO_2, 47.0. $(NH_4)_2Pb[Cu(NO_2)_6]$ requires Cu, 10.90 ; Pb, 35.54 ; NH_4, 6.20 ; NO_2, 47.39 per cent}.

7. *Potassium Lead Ferro-nitrite.*—The method described by Przibylla (*loc. cit.*) was found to give impure product contaminated with ferric hydroxide, resulting presumably from hydrolytic decomposition and oxidation of ferrous to ferric iron by the nitrous fumes evolved from the mixture. To avoid these the following procedure was adopted.

The preparation was made at a low temperature in a current of carbon dioxide in Kapsenberg's filtering apparatus as shown in the figure below. All water used in this preparation was previously boiled and cooled.

5.56 G. of doubly recrystallised (in presence of electrolytic iron and a little dilute sulphuric acid) $FeSO_4, 7H_2O$ (A.R. quality) and 14 g. of chemically pure lead nitrate (Kahlbaum) were made into a paste with 25 c.c. cold 60% absolute alcohol in a glass mortar. The solution containing ferrous and lead nitrate was filtered into a stoppered bottle and cooled in ice. Another solution was prepared by dissolving 4 g. of pure potassium nitrate (Merck) and 14 g. of sodium nitrite in the least quantity of water. The solution was made neutral to phenolphthalein, filtered into a stoppered bottle and cooled in ice. Now the lid A (*vide* Fig. 1) was fitted air-tight with grease to the filtering funnel B and held tightly by means of four clips ; the air inside was removed by allowing a stream of pure and dry carbon dioxide to enter through T_2 and escape by T_3, the stop-cocks T_1 and T_4 being closed. The apparatus was cooled by surrounding it with a piece of flannel soaked in a freezing mixture, and ice-cold water was allowed to drop continuously upon the flannel. Now the two solutions, prepared as above, were introduced into the apparatus through the small funnel F and the stop-cock T_1 was at once closed.

FIG. 1.
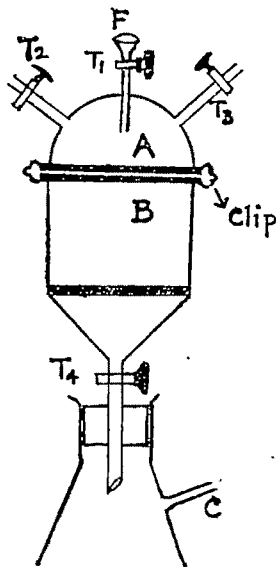
The mixture was left for about fifteen minutes with occasional shaking when the reaction took place in the vessel B. It was then allowed to settle for about 10 minutes. An orange-yellow precipitate separated out. Now the stop-cock T_4 was opened and T_3 closed. The passage of carbon dioxide was continued throughout the entire operation. The side-tube C of the filtering flask was then connected to the pump and the liquid was filtered off rapidly. The precipitate was then washed successively twice with small quantity of ice-cold water, thrice with 30% cold acetone and then with absolute alcohol. Finally it was washed several times with anhydrous ether. The wash liquids were introduced through F by opening T_1. The current of CO_2 was drawn through it for another 15 minutes and then the substance was taken out and dried for 20 minutes in a vacuum desiccator. The product was at once analysed and its susceptibility determined. {Found : Fe, 9.25, 9.31 ; Pb, 33.51, 33.32 ; K, 12.75 ; NO_2, 44.55. $K_2Pb[Fe(NO_2)_6]$ requires Fe, 9.08 ; Pb, 33.55 ; K, 12.64 ; NO_2, 44.73 per cent}.

8 (a). *Cobaltous Cyanide (hydrated)*.—5 G. of nickel-free, chemically pure, cobalt chloride (Scherring-Kahlbaum) were dissolved in 250 c.c. water ; a dilute solution of 2 g. chemically pure potassium cyanide (Merck) was added dropwise to the above solution and the mixture thoroughly stirred. Cobaltous cyanide was precipitated as an amorphous mass. The precipitate was allowed to settle on the water-bath and washed several times by decantation until the supernatant liquid was free from chloride. The substance was separated from the mother-liquor and the wash liquid by centrifuging. The product was finally washed with absolute alcohol. It was dried in air at about 30° to a constant weight (*cf.* Biltz and co-workers, *Z. anorg. Chem.*, 1928, **170**, 164). {Found : N, 18.10 ; Co, 37.70. $Co(CN)_2, 2.5H_2O$ requires N, 17.96 ; Co, 37.82 per cent}.

(b) *Anhydrous Cobaltous Cyanide*.—The hydrated cobaltous cyanide (*vide supra*) was weighed into a specially designed dehydration tube shown in the figure below.

Fig. 2.
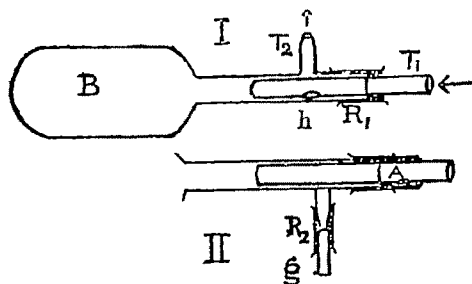
The tube T_1, one end of which is sealed, can be freely glided in or out of the neck of the small bulb tube B and is kept in position by means of a rubber tube R_1. There is a small hole at h in T_1. When T_1 is drawn out so that h reaches A, beyond the end of the neck of B, the hole is closed, and the connection between the bulb tube and the outside air is cut off (II-position). When h is in the position I, the bulb is open to the air. The end of the side tube T_2 is ground and fits tightly into the mouth of the susceptibility tube. T_2 can be closed by means of a small glass rod g fitting tightly in the rubber tube R_2. The dehydration tube containing the substance was placed in the cavity of an aluminium block fitted with a thermometer and heated by a micro-burner at the base. The air inside the bulb tube was expelled by a current of dry nitrogen gas from a cylinder. The gas entered through the hole of the sliding tube pushed inside as in position I and escaped through the side-tube. The substance was heated at 260-280° for several hours, the stream of nitrogen being maintained throughout the heating until the weight became constant. The nitrogen gas was dried by passing through conc. H_2SO_4 before it entered

the tube and escaped through T_3 connected with a wash-bottle containing conc. H_2SO_4. Before cutting off the nitrogen stream, T_1 was pulled out to close the hole and T_2 closed by a rubber tube and a small glass rod as already described. The heating was repeated till all water was removed, which was determined by weighing the apparatus (cf. Biltz and co-workers, loc. cit.). {Found : Co, 53.11. $Co(CN)_2$ requires Co, 53.15 per cent. Loss of H_2O, 29.10 ; calc., 28.85 per cent}.

9. (a) *Nickel Cyanide Trihydrate.*—6 G. of cobalt-free nickel sulphate heptahydrate (Scherring-Kahlbaum) were dissolved in 300 c.c. water and a dilute solution of Merck's chemically pure potassium cyanide (2.5 g.) was added to it drop by drop with constant stirring. Nickel cyanide separated in the form of a green amorphous precipitate. The precipitate was allowed to settle on the water-bath and washed repeatedly by decantation with hot water until the supernatant liquid was free from Ni. The substance was then separated from the mother-liquor by centrifuging. It was then stirred twice with absolute alcohol which was afterwards removed in the same manner. The product was dried in air to a constant weight (cf. Hofmann and Hochtlen, Ber., 1903, **36**, 1149). {Found : N, 16.95 ; Ni, 35.60. $Ni(CN)_2.3H_2O$ requires N, 17.0 ; Ni, 35.63 per cent}.

(b) *Nickel cyanide dihydrate* was prepared according to the method described by Hofmann and Hochtlen (loc. cit.). Cobalt-free nickel sulphate heptahydrate (5 g., Scherring-Kahlbaum) was dissolved in 20 c.c. water and added to a solution of 2.5 g. of chemically pure potassium cyanide (Merck) in 10 c.c. water. The precipitate of nickel cyanide was then dissolved by adding to the mixture 20 c.c. of liquor ammonia. After allowing the solution to stand for 15 minutes in ice, it was filtered through glass wool. The clear blue solution was kept aside for several days when with the gradual loss of ammonia layers of crystalline flakes separated from the solution. The crystals were filtered and washed free from nickel. They were finally washed with absolute alcohol and dried to a constant weight in air. {Found : N, 19.14 ; Ni, 40.10. $Ni(CN)_2.2H_2O$ requires N, 19.0 ; Ni, 40.01 per cent}.

(c) *Anhydrous Nickel Cyanide.*—The trihydrate, $Ni(CN)_2.3H_2O$, was heated in the dehydration tube (vide the preparation of anhydrous cobaltous cyanide) at 190-200° to a constant weight (cf. Biltz and co-workers, loc. cit. ; Vournasos, Compt. rend., 1919, **168**, 889). {Found : Ni, 53.10. $Ni(CN)_2$ requires Ni, 53.03 per cent. Loss of H_2O by heat, 32.83 ; calc. from $Ni(CN)_2.3H_2O$, 32.78 per cent}.

Measurement of Magnetic Susceptibilities.

The susceptibility of the above described substances was measured according to Gouy's method as described in a previous paper by one of us (cf. Rây and Ghosh, J. Indian Chem. Soc., 1943, **20**, 323). The mass susceptibility, χ_g, was calculated from the formula,

$$\chi_g = \frac{2l \times m(\text{change of weight in mg.})}{m \times H^2 \times 1.019},$$

the symbols represent values as stated in previous papers ($H = 10.15 \times 10^3$ gauss, $l = 9$ cm.). The correction due to air displacement being negligible in the present cases has

been ignored. The molecular susceptibility, X_M, has been corrected for atomic and ionic diamagnetism, the values and sources of which are mentioned below.

$K^+ = -14.9 \times 10^{-6}$

$CN^- = -13.0 \times$,,   Trew, *Trans. Faraday Soc.*, 1941, 37, 488.

$NH_4^+ = -13.3 \times$,,

$Pb^{2+} = -32.0 \times$,,   Theoretical (after Angus)

$Ca^{2+} = -10.4 \times$,,   ,,   ,,

$Cu^{2+} = -12.8 \times$,,

$Fe^{2+} = -$,,   ,,   Taken to be equal to that of Zn^{2+} due to almost

$Co^{2+} = -$,,   ,,   . equality of their ionic radii. *cf.* Kido, *Sci. Report*

$Ni^{2+} = -$,,   ,,   *Tohoku Imp. Univ.*, 1932, 21, 149, 288.

$H_2O = -12.96 \times 10^{-6}$

$NO_2 = -2.11 \times$,,   From Pascal's corrected values.

From the corrected gram atomic susceptibility for the central metal ion the value of its magnetic moment in terms of Bohr magneton was calculated from the well known relation,

$$\mu_B = 2.83 \sqrt{X_A \times T}$$

The results of measurement are recorded in the following table.

Substance.	Temp.	$X_g \times 10^6$	$X_M \times 10^6$	X_A or $X_{M(corr.)}$	$\mu_B.$
$K_2Ca[Co(NO_2)_6]$	24.3	2.97	1346	1411.6	1.83
$K_2Pb[Co(NO_2)_6]$	28	2.035	1262	1349.2	1.80
$K_2Ca[Ni(NO_2)_6], 3H_2O$	31	6.965	3530	3633.7	2.97
$K_4[Ni(NO_2)_6]$	32	6.861	3369	3453.2	2.90
$K_2Ca[Cu(NO_2)_6]$	27	2.893	1325	1390.6	1.83
$(NH_4)_2Pb[Cu(NO_2)_6]$	27	2.329	1357.5	1441.5	1.86
$K_2Pb[Fe(NO_2)_6]$	31	0.396	244.1	331.3	0.90
$Co(CN)_2, 2.5H_2O$	28	36.26	5656	5727.2	3.72
$Co(CN)_2$	29	40.35	4478	4516.8	3.30
$Ni(CN)_2, 3H_2O$	31	11.64	1917	1994.0	2.20
$Ni(CN)_2, 2H_2O$	32.5	14.11	2069	2133.0	2.28
$Ni(CN)_2$	33.5	1.23	135.8	173.8	0.65

DISCUSSION

The magnetic moment for the central cobaltous atom in the case of $K_2Ca(Pb)[Co(NO_2)_6]$ has been found to be 1.83 and 1.80 Bohr respectively. A value of 1.9 μ_B for the potassium-calcium salt has been recorded by Pauling in his book, "The Nature of the Chemical Bond, 1940, p. 116." The results closely accord with the expected theoretical value for the six co-valent penetration cobaltous complexes with d^2sp^3 octahedral bonds on the

basis of Bose-Stoner's formula for one unpaired electron with quenched orbital moments. This is evident from the following scheme of electronic distribution in the complex :
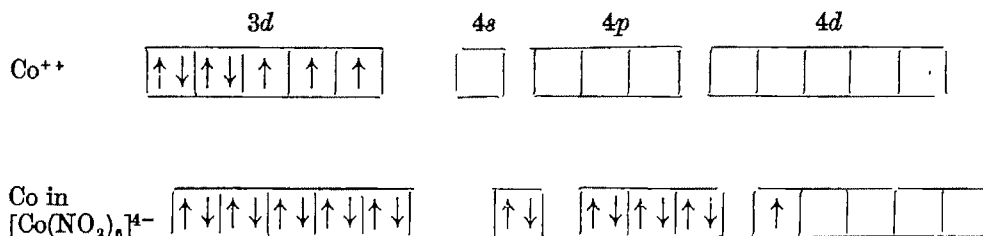
This shows that the triple nitrites of dyad cobalt belong to the penetration type of octahedral complexes.

The magnetic moment of the central nickel atom in its double and triple nitrites has been found to lie between 2.90 and 2.97 Bohr. Nickel atom, in an octahedral complex of the penetration type forming d^2sp^3 bonds, must have two of its $3d$ electrons promoted to a higher level where they may remain unpaired. This should give rise to a magnetic moment, according to Bose-Stoner's formula, $\mu_B = \sqrt{4S(S+1)}$, of $\sqrt{8}$ or 2.83 Bohr magnetons ,which agrees with the observed values. This holds good also for the simple Ni^{++} ion as well as for the associated tetrahedral or octahedral complexes of sp^3 or sp^3d^2 type respectively, with orbital moments completely quenched. But the observed magnetic moment for the simple Ni^{++} ion varies from 3.2 – 3.44 Bohr. This is obviously due to a small contribution from the partially frozen orbital moments. This quenching effect is likely to be greater in octahedral d^2sp^3 penetration complexes with their stronger bonds. Besides, the electrons responsible for the magnetic moment in their case, being promoted to the outermost level, are fully exposed to the influence of the field of the neighbouring ions whereby their orbital moments are more or less completely quenched. This is clear from the following scheme.
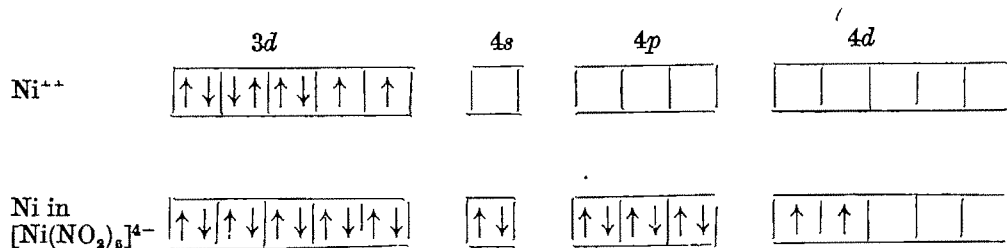
It appears from these considerations that the complex $[Ni(NO_2)_6]^{4-}$ approaches the character of octahedral d^2sp^3 complex of the penetration type.

The μ_B-value of the central bivalent copper atom in its triple nitrites has been found to lie between 1.83 and 1.86, which is distinctly lower than that of Cu^{++} ion in simple salts

which lies about 2.0 Bohr due to incompletely quenched orbital moment of the single unpaired electron in Cu^{++} ion. The lower value in $[Cu(NO_2)_6]$ suggests that the complex possibly belongs to the associated type with the formation of octahedral sp^2d^2 bonds as shown below.

	3d	4s	4p	4d
Cu^{++}	↑↓ ↑↓ ↑↓ ↑↓ ↑	☐	☐ ☐ ☐	☐ ☐ ☐ ☐ ☐
Cu in $[Cu(NO_2)_6]^{4-}$	↑↓ ↑↓ ↑↓ ↑↑ ↑	↑↓	↑↓ ↑↓ ↑↓	↑↓ ↑↓ ☐ ☐
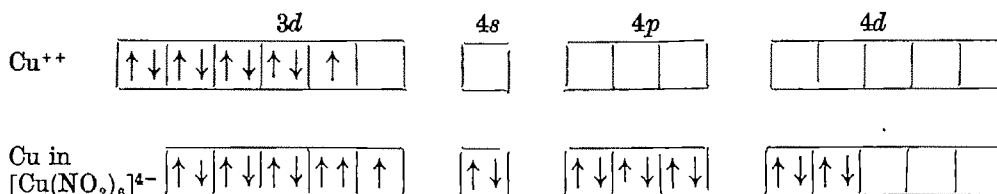
The magnetic moment for the bivalent iron atom in its triple nitrite has been found to be 0.9 Bohr as against 5.3 μ_B for Fe^{++} in simple iron salts. This abnormal reduction in the moment value is a strong evidence in favour of the formation of an octahedral penetration complex with d^2sp^3 hybrid bonds. Strictly speaking the moment should have been zero as shown in the following electronic configuration. The small paramagnetic moment observed is possibly due to the slight decomposition of the compound which is difficult to avoid. A similar value of 1 μ_B has also been reported by Cambi, Ferrari and Colla (*Gazzetta*, 1936, **65**, 1162).

	3d	4s	4p	4d
Fe^{++}	↑↓ ↑ ↑ ↑ ↑	☐	☐ ☐ ☐	☐ ☐ ☐ ☐ ☐
Fe in $[Fe(NO_2)_6]^{4-}$	↑↓ ↑↓ ↑↓ ↑↑ ↑↓	↑↓	↑↓ ↑↑ ↑↓	☐ ☐ ☐ ☐
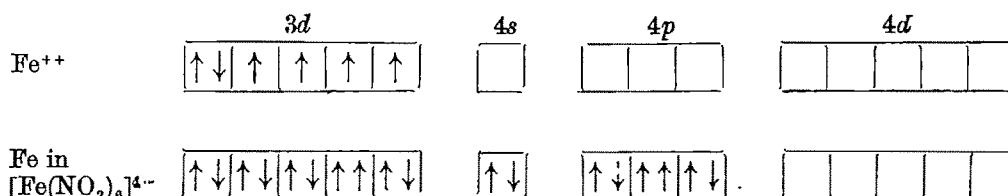
The magnetic moment of hydrated and anhydrous nickel cyanides has been determined by various workers. The results are given below in a tabular form.

$Ni(CN)_2, 7H_2O$ (Bose, *Nature*, 1930, **125**, 708)	..	3.0 Bohr approx.
$Ni(CN)_2, 4H_2O$ (Cambi, *Gazzette*, 1934, **64**, 758)	..	2.38 Bohr
$Ni(CN)_2, 2H_2O$ (Cambi, *loc. cit.*)	..	2.28 Bohr
(Fereday, *Proc. Phys. Soc.*, 1934, **46**, 214)	..	2.46 Bohr
$Ni(CN)_2$ (Cambi, *loc. cit.*)	..	1.0 Bohr
(Fereday, *loc. cit.*)	..	0.96 Bohr
(Bose, *loc. cit.*)	..	Practically diamagnetic
(Seres, *Annal. Physik*, (10) 1933, **20**, 441)	..	1.2 Bohr

The values obtained in the present investigation are :—

$Ni(CN)_2.3H_2O$, 2.2 Bohr ; $Ni(CN)_2.2H_2O$, 2.28 Bohr ; $Ni(CN)_2$, 0. 65 Bohr.

It is seen that the value for $Ni(CN)_2.2H_2O$ agrees closely with that given by Cambi. The somewhat lower value for the trihydrate is rather unusual, if the possibilities of errors

from extraneous sources are excluded. In any case it seems that there is little difference' between the two hydrates so far as their magnetic properties are concerned. The observed slight difference might be attributed to their physical nature, one being amorphous and the other crystalline. The observed moment value for the anhydrous cyanide is lower than those given by Cambi, Fereday and Seres, but is not diamagnetic as reported by Bose. These lower values for the hydrated cyanides and notably the much lower one for the anhydrous substance in comparison with the moment value of 3.2 to 3.4 Bohr for the simple Ni^{++} ion seem to suggest, as pointed out by Pauling, that the hydrated cyanides are formed by the combination of the square (dsp^2) co-valent complex $[Ni(CN)_4]^-$ with the tetrahedral (sp^3) or ionic complex $[Ni(H_2O)_4]^{++}$, or even with the octahedral (sp^3d^2) co-valent or ionic complex $[Ni(H_2O)_6]^{++}$ in different proportions. Comparing the values obtained for the hydrated cyanides with that of the simple nickelous ion it can be concluded that in these cyanides about 70% of nickel atoms occur in the form of ionic and 30% in that of planar square complex, $[Ni(CN)_4]^-$, with dsp^2 bonds. The value for the anhydrous cyanide is only about 20% of that for the nickelous ion. Hence 80% of Ni atom in its molecule form planar square complex (dsp^2 bonds) with carbon and nitrogen of the cyanogen group. The anhydrous cyanide may accordingly be represented in the form of a polymerised molecule to give a chain-like structure as shown below :
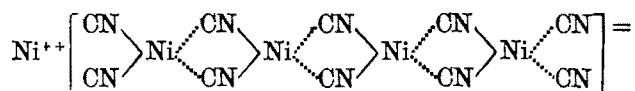
or briefly $Ni[Ni_4(CN)_{10}]$.

The possible formation of a still more highly polymerised product depending upon the method of preparation cannot, however, be excluded.

No measurement of magnetic moment for the hydrated and anhydrous cobaltous cyanide is recorded in the literature. The moment value observed for the hydrated cyanide, $Co(CN)_2 \cdot 2.5H_2O$, is 3.7 Bohr and that for the anhydrous cyanide is 3.3 Bohr magnetons. The moment value for the cobaltous ion or of the cobaltous atom in its tetrahedral (sp^3), octahedral (sp^3d^2) and ionic complexes varies between 4.5 and 5.2 Bohr magnetons, which is greater than the theoretically calculated value of 3.88 μ_B for the three unpaired d-electrons due to incomplete quenching of their orbital moments. The moment values for the hydrated and anhydrous cyanides may be explained either on the basis of more or less complete quenching of orbital moments of the cobaltous ion forming virtually an ionic complex or on the supposition that the formation of planar square complex with dsp^2 hybrid bonds has occurred to a certain extent. A few 4-covalent cobaltous complexes of the penetration type have recently been examined from magneto-chemical standpoint by Rây and Ghosh (*J. Indian Chem. Soc.*, 1943, 20, 323), who found for these an average μ_B-value of 2.6, instead of the theoretical value of 1.73 Bohr according to Bose-Stoner's formula on the basis of spin moment alone. This shows that in these planar square cobaltous complexes of the penetration type, the orbital moment is only partially quenched. It might be, therefore, reasonably suggested that in the hydrated and anhydrous cobaltous cyanides the cobaltous atom is present both in the form of a

STUDIES IN GLASS SYSTEMS. REFRACTOMETRIC STUDIES OF ALKALI HALIDES DISSOLVED IN BORAX GLASS

By Subodh Kumar Majumdar and Bhupati Kumar Banerjee

Salts like LiCl, NaCl, KCl and NaI were dissolved in fused borax glass and the mole-refraction of the solidified glasses were determined. The mole-refraction of the dissolved salts calculated from the additivity formula shows considerable departure from values in the crystalline state and at infinite dilution. The concentration—mole. refraction curves for all these salts show a positive slope unlike the case in aqueous solutions. But the values are considerably smaller than those of the crystal and for infinite dilution, showing the existence of a very considerable deformation in the glass system. The positive character of the slope is explained as due to decreased dissociation of the salt in the glass medium. On the whole Fajans deformation rule is qualitatively established for solid solutions of these salts in glass systems.

Fajans and co-workers have done a considerable amount of work on the mole-refraction of different salts, possessing ions of inert gas configuration, in the solid crystalline state, in the state of vapour and in aqueous solutions (Fajans and Joos, *Z. Physik*, 1924, **23**, 1; Fajans, *Trans. Faraday Soc.*, 1927, **23**, 357; Fajans, *Z. Elektrochem.*, 1928, **34**, 502; Wulff and Schaller, *Z. Krist.*, 1934, **87**, 43; Geffcken, *Z. physikal. Chem.*, 1929, **B 5**, 81, etc.). Majumdar and co-workers (*Z. physikal. Chem.*, 1936, **B, 31**, 319; *J. Indian Chem. Soc.*, 1942, **19**, 241, 461; 1946, **23**, 317; 1945, **22**, 147) have studied the behaviour of different polar salts dissolved in boric oxide and borax glasses. With the alkali halides, dissolved in boric oxide glass, they have found that these salts are very strongly deformed in solid solution and the relative deforming power of the cations on the common anion obeys Fajans deformation rule qualitatively. It was therefore thought interesting to extend the studies to as many glass solvent media as possible. An added advantage which such systems possess over those studied before is that the samples are less liable to the action of moisture and they therefore remain clear quite a long time.

The deforming action of the ions of a molecule on each other and on the surrounding solvent medium may be classified as follows :—

(i)	Action of the cation on the anion	..	Decrease in mole-refraction	
(ii)	„	anion „ cation	..	Increase „
(iii)	„	anion on the solvent	..	Increase „
(iv)	„	cation „	..	Decrease „

A typical example of the decrease of mole-refraction with concentration is furnished by LiCl in aqueous solution. A decrease in the mole-refraction value occurs by the transition of LiCl at infinite dilution to the state of the crystal. Thus

$$\triangle R = R_{cryst.} - R_{sol'.} = 7.59 - 8.74 = -1.45.$$

In this case owing to the small ionic diameter of Li$^+$ ion and its strong hydration, the effects (i) and (iv) preponderate over those of (ii) and (iii) and hence the mole-refraction—concentration curve shows a negative slope. In the case of crystal, the effect of

deformation is maximum and hence minimum value of mole-refraction is given by it. And this is true in a greater or lesser degree with aqueous solutions, according to concentration. In the case of a salt like KF, on the other hand, the effect of the anion on the cation is greater than that of cation on anion and thus the mole-refraction—concentration curve shows a positive slope. As has been shown by Majumdar *et al.* (*loc. cit.*) with boric oxide as the solvent medium and as will appear from the present paper, a much smaller value of mole-refraction is obtained for LiCl when dissolved in such glasses.

According to the Lorenz-Lorentz formula, the mole-refraction R of a pure substance is given by

$$R = \frac{n^2 - 1}{n^2 + 2} \cdot \frac{M}{d} \qquad \qquad \ldots \quad (1)$$

where n is the refractive index and d, the density of the substance and M, its molecular weight. Strictly speaking n should be the refractive index for infinitely long wave-length, if R is to be taken as a measure of the polarisability of the molecule. In this case $n^2 = \epsilon$, where ϵ is the dielectric constant of the medium and the Lorenz-Lorentz equation changes to the well known Clausius-Mosotti equation. For the purpose of comparison, however, the refractive index for a particular visible wave-length (D-line) may be taken without serious error. In a glass system consisting of p per cent of alkali chloride XCl and therefore of $(100-p)$ per cent borax, if r be the specific refraction of the glass mixture, r_1, that of the alkali chloride and r_2, the value for fused borax glass, then the following relation should hold good, if the additivity rule is obeyed by the mixture :

$$100 \, r = p.r_1 + (100-p).r_2 \qquad \qquad \ldots \quad (2)$$

The specific refraction r of the glass mixture can be calculated from the experimental values of n and d from the formula

$$r = \frac{n^2 - 1}{n^2 + 2} \cdot \frac{1}{d}.$$

The value of r_2 can be similarly found from pure fused borax glass. Hence from equation (2), the specific refraction of the dissolved alkali halide and hence its mole-refraction may be calculated. This is on the assumption, however, that the refractivity of the solvent remains unchanged. This value of mole-refraction of XCl in glass may be conveniently compared with its values in the crystal and in aqueous solution at infinite dilution.

<div align="center">EXPERIMENTAL</div>

Preparation of the samples.—An aqueous solution of LiCl, which as is well known is hygroscopic, was evaporated to dryness in a platinum crucible and the residue quickly taken up with absolute alcohol. There was usually a small insoluble residue left. The alcoholic solution was filtered and the alcohol evaporated off, The residue was kept in a vacuum desiccator before use. The other chemicals (Merck, pro-Analyse quality) were recrystallised once and used. Borax was powdered and dehydrated first in a hot air oven and then in a vacuum desiccator for several days, until a sample taken up with absolute alcohol did not impart any coloration to anhydrous $CuSO_4$. Complete dehydration of borax before fusion is necessary, as otherwise the glasses tenaciously retain traces of moisture which would be difficult to remove later (*cf.* Consen and Turner, *J. Chem. Soc.*, 1928, 2654). The salts were similarly dehydrated beforehand and different samples of

borax and alkali halides were powdered and heated in a platinum crucible in an electric furnace to about 1000° until a thoroughly homogeneous melt was obtained. The platinum crucible was then chilled and the solidified glass extracted. A portion of the ingredients first sublimed but later a melt of constant composition was obtained. Each sample was examined in a Polarisation microscope and only those pieces which were optically isotropic were taken. Platinum possesses a different coefficient of expansion from the melt and hence when the melt solidifies great stress is brought to bear on the system with the result that there is chance of the solid being double refracting. It should be noticed that although borax crystals are optically anisotropic, borax glass, if properly prepared, is isotropic. This is an additional proof of Warren's view that in a glass the constituents form a sort of non-periodic network as opposed to the periodic space lattice present in a true crystal.

Analysis of the samples.—The halogen content of the samples was determined at first volumertrically by back titration method and then checked in some cases by gravimetric precipitation. About 1.5 g. of the glass was dissolved in hot water and made up to 100 c.c. An aliquot part was taken and treated with a definite volume of standard $AgNO_3$ adding excess of nitric acid. The excess of silver nitrate was back titrated against standard NH_4CNS using ferric alum as indicator.

Density determination.—The densities of the samples were determined according to the method detailed in a previous paper (Majumdar and Sarma, *loc. cit.*). A small particle of the glass was suspended in a mixture of acetylene tetrabromide and toluene and the container vessel kept in a transparent thermostat maintained at 35°. The composition of the suspension liquid was altered until the particle remained suspended in any position. The exact point was reached by noting the movement of the particle several times up and down. At this point the liquid mixture was introduced into a weighed pyknometer joined by a tube with ground glass stopper and also placed in the thermostat. The usual precautions were taken and the weight of the pyknometer again determined. Two independent determinations were made with each sample and the mean value taken.

Refractive Index determination.—The refractive index of the samples was determined by the Becke method followed by the determination of the refractive indices of the two liquid mixtures in a Pulfrich refractometer, sodium light from an Osram sodium lamp being used for both the measurements. It is well known that refractive index determination of solids presents considerable difficulties. Direct determination of refractive index of a solid is possible in a Pulfrich refractometer if the solid is ground in the shape of a right angled prism with optical plane faces. This is, however, not possible in the present case.

A small piece of the solid was suspended in a liquid mixture and focussed in sodium light in a high power microscope. The composition of the liquid was then varied and the eye piece was raised after focussing. If the refractive indices of the solid and liquid are very nearly equal, either of the two effects are observed on raising the eye piece ; either the outline of the solid-liquid recede away from the solid or the lines seem to enter the solid. In the former case the refractive index of the solid is less than that of the liquid and *vice versa.* Hence by choosing two liquids, one having a higher and the other a lower refractive index than the solid and adjusting the composition carefully, two liquid

mixtures may be obtained, the refractive indices of which are respectively only slightly higher and slightly lower than the solid itself. The refractive indices of these two are then accurately determined in a Pulfrich refractometer and the mean value taken ; the two values usually varied in the fourth place of decimal. The determinations had to be carried out at room temperature, but as solids possess a very small temperature coefficient of refractive index (less than the experimental error in this case), this introduced no serious error in the comparative values.

TABLE I

$Cg/100g$-Conc. in g. equiv./1000g. borax. n_D=Ref. index in D-light.

LiCl	$Cg/1000$ g.	Density.	n_D.	NaCl.	$Cg/1000$ g.	Density.	n_D.
\multicolumn{4}{l}{LiCl-borax glass.}	\multicolumn{4}{l}{NaCl-borax glass.}			
0	0	2.3557	1.5151	5.1%	0.87	2.3349	1.5050
2.0%	0.47	2.3501	1.5099	6.5	1.11	2.3281	1.5031
5.2	1.22	2.3297	1.5038	10.0	1.71	2.3075	1.4958
7.5	1.77	2.3122	1.5022	11.5	1.97	2.2998	1.4950
9.6	2.26	2.2961	1.5011	14.3	2.44	2.2907	1.4944
				14.8	2.53	2.2887	1.4935
				18.8	3.21	2.2653	1.4911

KCl.	$Cg/1000$ g.	Density.	n_D.	NaI	$Cg/1000$ g.	Density.	n_D.
\multicolumn{4}{l}{KCl-borax glass.}	\multicolumn{4}{l}{NaI-borax glass.}			
7.76%	1.04	2.3296	1.5057	3.12%	0.21	2.3902	1.5154
10.76	1.44	2.3125	1.5047	4.45	0.29	2.4021	1.5159
14.89	1.99	2.2940	1.4997	9.33	0.62	2.4411	1.5219
16.45	2.20	2.2673	1.4955				

In the following tables, r_{XCl} and hence R_{XCl} for the alkali halide dissolved in borax glass are calculated from the mixture law ; the respective values of R at infinite dilution and in pure crystal are shown in the last column. The value of r for pure borax is taken as 0.1278 (Wulff and Majumdar, *loc. cit.*).

TABLE II
LiCl—borax glass.

LiCl.	r_{mix} (obs.).	r_{LiCl} (calc)..	R_{LiCl} (calc..)	R_{sol}.	R_{cryst}.
2.0%	0.1270	0.0810	3.44		
5.2	0.1268	0.1057	4.47	8.76	7.59
7.5	0.1276	0.1230	5.22	Fajans, Kohner and Geffcken,
9.6	0.1283	0.1312	5.57	(Z. Electrochem.,1925, 84, 2)

TABLE III
NaCl—borax glass.

NaCl.	r_{mix} (obs.).	r_{NaCl} (calc.).	R_{NaCl} (calc.).	R_{sol}	R_{cryst}.
5.1%	0.1262	0.0929	5.43		
6.5	0.1269	0.1121	6.55	9.27	8.52
10.0	0.1265	0.1135	6.63		
11.5	0.1268	0.1177	6.88		
14.3	0.1270	0.1211	7.08		
14.8	0.1269	0.1211	7.08		
18.8	0.1278	0.1273	7.44		

DISCUSSION

With all the four salts investigated, two things come out prominently. First, in every case, the mole-refraction of the dissolved salt increases with concentration and secondly the highest value obtained for the maximum concentration is very considerably smaller than that of the pure salt either in the crystalline condition or in aqueous solution at infinite dilution. The positive slope of the mole-refraction—concentration curve (*vide*

TABLE IV

KCl—borax glass.

$R_{sol.} = 11.31$ $R_{cryst.} = 10.83$

KCl	r_{mix} (obs.).	r_{KCl} (calc.).	R_{KCl} (calc.).
7.76%	0.1274	0.1211	9.02
10.76	0.1281	0.1310	9.76
14.89	0.1281	0.1279	9.52
16.45	0.1286	0.1317	9.81

TABLE V

NaI — borax glass.

$R_{sol.} = 19.38$ $R_{cryst.} = 17.07$

NaI	r_{mix} (obs.).	r_{NaI} (calc.).	R_{NaI} (calc.).
3.12%	0.1262	0.0702	10.53
4.45	0.1257	0.0767	11.50
9.33	0.1249	0.0948	14.20

FIG. I
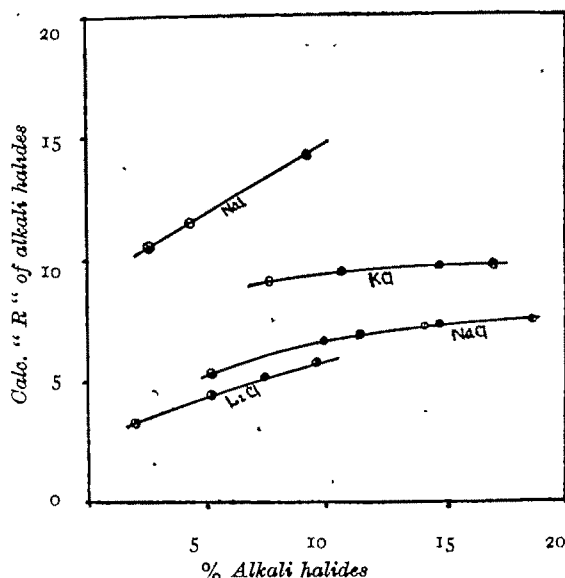
Fig. 1) stands in remarkable contrast to the usual negative slope in aqueous solutions (Fajans, Z. Elektrochem,, loc. cit.). With the three chlorides investigated, in aqueous solutions, the effects of the cation on the anion and the cation on the solvent medium greatly outweigh the other two effects and hence the mole-refraction decreases with increasing concentration. And it should be remembered in this connection that Li^+ ion most of all and the other two cations in varying degrees are heavily hydrated in solution. The negative slope is very pronounced in the case of NaI in aqueous solution, because the effect (i) has a greater magnitude on the larger iodine ion than in NaCl with a smaller anion. On the other hand, the positive slope of chlorates and sulphates in aqueous solution is explained by the fact that ClO_4' ion is less polarisable than the water molecule and therefore the effect of the anion on the solvent preponderates. This has been found to be the case with $NaClO_4$, $LiClO_4$, $Al(ClO_4)_3$, the different sulphates and also with KF. Viewed in this light, the positive slope of the curves in the cases investigated in the present paper points either to the interaction of the anion with the solvent medium, not necessarily in a chemical sense, or to a decreased dissociation of the salt with increasing concentration.

It may be mentioned that some exceptions have been found by the workers of the Fajans schools of the general rule that whenever the cation is either small or highly charged and the anion large, the effect of increasing concentration will be increased refraction. Simple nitrates like $NaNO_3$, KNO_3, etc. are found to give a negative slope in aqueous solutions and this is explained by the unsymmetrical distribution of the oxygen octets round the central nitrogen atom in the nitrate ion (Fajans, Z. physikal. Chem., 1938, 137, 381). In SO_4'' ion on the other hand, the four oxygen octets are symmetrically distributed round the central sulphur atom. And this is also true of ClO_4' ion.

The positive slope of the curves in aqueous solutions of the above mentioned salts may thus be explained as due to either of the two following effects :—The field of the

cation is so strongly polarised by that of the anion that the polarising effect of the cation on the solvent medium, which brings about decreased refraction, is practically removed and hence a resultant increase of refraction with concentration results. An alternative suggestion is that the hydration layer of the cation is replaced partially (in the case of a polyvalent cation) or wholly by an anion which really amounts to a decreased dissociation of the salt. In the case of salts with polyvalent cations like $Al(ClO_4)_3$, therefore ions like ClO_4Al^{++} will exist in solution. Hence the effect will be less marked than in the case of a salt like $NaClO_4$, in which decreased dissociation of the salt with increased concentration is supposed to be the principal cause of the positive slope. Judged by this standard one can conclude that in the cases of the halides, dissolved in borax glass studied by us, there is evidence of the existence of undissociated molecules. This is understandable from the difference in dielectric constant between water and borate and boric oxide glasses. A negative slope of the curves therefore is not to be expected as in the case of the corresponding aqueous solutions. This does not mean, however, that the dissolved salts retain their lattice dimensions unaltered when in a state of solution in the glass. For reasons explained in previous communications (Majumdar and Palit, loc. cit.), an enlargement of lattice dimensions may be expected on theoretical considerations. The experimental evidence on this point, however, has been conflicting (Majumdar, Banerjee and Banerjee, Nature, 6th Oct., 1945) and the investigation is being pursued further.

Turning to the experimental results we find that the calculated value of R for LiCl in glass is remarkably small, the value increasing from 3.44 to 5.57 corresponding to concentrations 0.47 to 2.26/1000 g. The values of LiCl in the pure crystal and at infinite dilution in aqueous solution are respectively 7.59 and 8.76. The positive slope of the curve is quite pronounced. It may be mentioned in this connection that $LiClO_4$ also gives a positive slope in aqueous solution, although LiCl as usual gives a negative slope. For NaCl, the increase in value of R is from 5.43 to 7.44 corresponding to a concentration increase from 0.87 to 3.21 g. equiv. salt/1000 g. borax. The values of R for the pure salt, in the crystal and at infinite dilution are respectively 8.52 and 9.27. For KCl, the value increases from 9.02 to 9.81 for a concentration change from 1.04 to 2.20 g. equiv. salt/1000g borax. Thus it is clear that *qualitatively* the effect of concentration on the mole-refraction of the dissolved salt follows the inequality $Li^+>Na^+>K^+$, as can be expected from Fajan's Deformation Theory.

The case of NaI dissolved in borax stands out in prominent contrast with its behaviour in aqueous solution. In aqueous solution NaI gives a very *steep* negative slope in the concentration—refraction curve. In borax solution on the contrary there is an equally prominent positive slope, the value of R increasing from 10.53 to 14.20 between a concentration increase 0.21 and 0.62 g. equiv. salt/1000 g. borax. The question of cationic exchange between the salt and the solvent to which reference has been made does not arise in this case as well as in the case of NaCl. It is clear therefore that while in aqueous solution, the refractometric evidence points to a large dissociation even in concentrated solution, in solution in borax glass, it shows considerably decreased dissociation and a very considerable deformation.

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THE MAGNETIC STUDY OF PERIODATES. PART II. THE STRUCTURE OF PERIODATES OF SODIUM, SILVER, MERCURY AND LANTHANUM

By Roop Chand Sahney, S. L. Aggarwal and Sardar Mahan Singh

The magnetic susceptibilities of the periodates of Na, Ag, Hg and La have been determined. Experimental values χ_M have been compared with the χ_M calculated from the theoretically possible formulae of these periodates. From this comparison definite conclusions regarding the structure of these periodates have been arrived at.

In a previous communication (*J. Indian Chem. Soc.*, 1945, 22, 158) one of us reported the magnetic susceptibilities of periodic acid in the solid state and in solutions of different concentrations with a view to ascertaining its constitution. The χ_M of the acid in the solid state and in its solutions are almost equal and it was shown that the acid existed as $HIO_4.2H_2O$. This paper deals with the magnetic susceptibilities of some metallic periodates which correspond to a number of periodic acids derived from the union of different molecules of water with the hypothetical I_2O_7 molecule as shown below.

<div align="center">TABLE I</div>

Hypothetical I_2O_7 with	Formula of the acid.	Name of the acid.	Salts known.
$7H_2O$	H_7IO_7	Orthoperiodic acid	No salt known
$6H_2O$	$H_{12}I_2O_{13}$	Diorthoperiodic acid	$Zr_3I_2O_{13}.14H_2O$
$5H_2O$	H_5IO_6	Paraperiodic acid	Ag_5IO_6
$4H_2O$	$H_8I_2O_{11}$	Diparaperiodic acid	$Li_8I_2O_{11}.2H_2O$
$3H_2O$	H_3IO_5	Mesoperiodic acid	Ag_3IO_5
$2H_2O$	$H_4I_2O_9$	Dimesoperiodic acid	$Ag_4I_2O_9$
H_2O	HIO_4	Metaperiodic acid	KIO_4, $NaIO_4$, etc.

The structure of these metallic periodates is still a matter of some speculation. From analytical results it is not possible to say whether a particular periodate is a hydrated salt of one acid or acid salt of another. Thus for example the periodate of the composition $2Na_2O.I_2O_7.3H_2O$ can either be secondary sodium paraperiodate $Na_2H_3IO_6$ or sodium dimesoperiodate $Na_4I_2O_9, 3H_2O$.

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The magnetic susceptibility determinations of some periodates have now been under-taken with a view to discussing their structures. χ_M of these periodates have been calculated theoretically and compared with the experimental values. From this comparison definite conclusions regarding the structures of periodates have been arrived at.

EXPERIMENTAL

Pure 'Analar' salts were used in the preparation of periodates :

1. *Secondary sodium paraperiodate* was prepared by the method of Partington and Bahl (*J. Chem. Soc.*, 1934, 1088). The precipitate was repeatedly washed to free it from iodide, chloride and iodate. (Found : Na, 16.67 ; I, 46.80 ; O_2, 20.1. $Na_2H_3IO_6$ requires Na, 16.91 ; I, 46.69 ; O_2, 20.58 per cent) according to the decomposition :

$$4Na_2H_3IO_6 \rightarrow 4Na_2O + 2I_2 + 3H_2O + 7O_2.$$
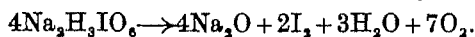
2. *Silver mesoperiodate* was prepared by the method of Wells (*Amer. Chem. J.*, 1901, 26, 278). (Found : Ag, 61.2 ; I, 24.1 ; O_2, 14.9. Ag_3IO_5 requires Ag, 61.0 ; I, 23.84 ; O_2. 14.87 per cent) according to the equation

$$2Ag_3IO_5 = 2AgI + 4Ag + 5O_5.$$

3. *Diargentous paraperiodate* was prepared by adding $Na_2H_3IO_6$ in dilute nitric acid to a solution of $AgNO_3$ and filtering. The filtrate on cooling gave a crop of yellow crystals of $Ag_2H_3IO_6$. (Found : Ag, 44.8 ; I, 29.3 ; O_2, 16.2. $Ag_2H_3IO_6$ requires Ag, 48.86 ; I, 28.73 ; O_2, 16.28 per cent) according to the decomposition

$$4Ag_2H_3IO_6 \rightarrow 4AgI + 4Ag + 6H_2O + 9O_2.$$
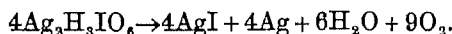
4. *Mercuric diparaperiodate* was prepared by adding $Na_2H_3IO_6$ in dilute nitric acid to a solution of $Hg(NO_3)_2$. (Found : Hg, 65.7 ; I, 20.92 ; O_2, 14.03. $Hg_4I_2O_{11}$ requires Hg, 65.5 ; I, 20.72 ; O_2, 14.28 per cent).

5. *Dihydrated lanthanum mesoperiodate* was prepared by the addition of $Na_2H_3IO_6$ in dilute nitric acid to lanthanum nitrate solution. The salt was obtained as a white powder. (Found : La, 35.32 ; I, 36.5 ; O_2, 13.32. Calc. for $LaIO_5,2H_2O$: La, 35.07 ; I, 36.33 ; O_2, 12.57 per cent) according to decomposition

$$2LaIO_5, 2H_2O = 2LaO_2 + 4H_2O + 3O_2.$$
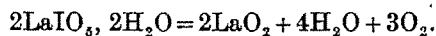
Susceptibility Determinations.

The susceptibilities were determined by the modified Guoy's method (Nevgi, *Current Sci.*, 1935, 4, 403). Conductivity water ($\kappa = 0.72 \times 10^{-6}$) was used as the reference substance and the method was standardised by making determinations on compounds of known

values of susceptibility. The results of known substances with % error are reported in Table II and susceptibility values of periodates in Table III.

TABLE II

Susceptibility $\times 10^6$

Substance.	Mean of three readings.	Reported value.	Error.
1. KCl	0.514	0.516	0.2%
2. Naphthalene	0.719	0.717	0.3
3. Trinitrobenzene	0.350	0.352	-0.3
4. Camphoric anhydride	0.624	0.622	0.3
5. Ethyl alcohol	0.743	0.744	0.1

TABLE III

Substance.	Susceptibility per g. (mean of three readings).	per mol.
1. Disodium paraperiodate	0.257×10^{-6}	69.9
2. Silver mesoperiodate	0.233	123.64
3. Diargentous paraperiodate	0.2256	99.66
4. Mercuric diparaperiodate	0.1828	225.55
5. Dihydrated lanthanum mesoperiodate	0.1591	60.76

DISCUSSION

The molecular susceptibility of a polar salt may be considered as the sum of the susceptibilities of its ions.

$$\chi_{salt} = \chi_{cation} + \chi_{anion}$$

The ionic susceptibilities have been derived by a number of different methods and also from theoretical considerations (Miss Trew, *Trans. Faraday Soc.*, 1941, **37**, 476). The average value for Na^+ is 6.8×10^{-6}. The hydrogen ion is generally considered to have zero ionic susceptibility in the solid acids. Miss Trew (*loc. cit.*) has suggested a method for calculating the ionic susceptibility of metaperiodic acid ion (IO_4) from IO_3 as follows :

Ionic susceptibility of IO_4 = (Ionic susceptibility of IO_3 + susceptibility of 4O)—depression due to I—O bond.

The depression of diamagnetism was calculated to be —4.33 units by comparing the atomic susceptibility for 3 oxygen atoms with the values obtained by subtracting the ionic susceptibility of I' ion from that of IO_3 ion. The value of IO_4 ion calculated is —51.7. This value is in excellent agreement with the experimental value —51.8 (reported by Aggarwal and Singh, *loc. cit.*). This also agrees within experimental error with Kido's value of —53.4.

The above simple method for calculating ionic susceptibility of IO_4 ion can be extended to other oxyhalogen ions. The ionic susceptibilities of IO_4, IO_5, IO_6 and I_2O_9 ions are calculated as below :

Calculation of ionic susceptibility of IO_4 *ion.**

$$\chi_{IO_3} \quad = \quad -51.6$$
$$\chi_I \quad = \quad -50.8$$

for 3 oxygen atoms	—	−0.8
Pascal's value for three oxygen atoms	—	−13.8
Depression due to 3(I—O) bonds	—	−13.8—(—0.8)=—13
Depression due to I—O bond	—	−13/3=—4.33

Therefore ionic susceptibility of IO_4 ion=

($\chi_{I'}$+susceptibility of 4 oxygen atoms)—depression due to 4(I—O) bonds

$$=[\underset{I}{(-50.6)} \quad + \quad \underset{4O}{(-18.4)} - (-17.3)] = -51.7$$

Similarly ionic susceptibilities of IO_5 and IO_6 ions are calculated as −51.97 and —52.24 respectively.

Ionic susceptibility of I_2O_9 *ion.*—I_2O_9 can be represented by the formula
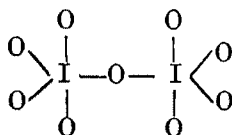
I_2O_9 can be split into two portions IO_5 and IO_4 ions and there is only one I—O bond connecting the two portions.

Hence the ionic susceptibility of $I_2O_9 = \chi_{IO_5} + \chi_{IO_4}$ – depression due to I-O bond

$$=(-51.97-51.7)-(-4.33)=-99.32.$$

It is now possible to derive the structure of metallic disodium paraperiodate which corresponds to two salts of the possible periodic acids, *i.e.*, either it can be $Na_2H_3IO_6$ or $Na_4I_2O_9.3H_2O$. The molecular susceptibilities of these are calculated by adding the susceptibilities of ions as below.

TABLE IV

Calculations of $\chi_M Na_2H_3IO_6$		Calculations of $\chi_M Na_4I_2O_9.3H_2O$	
$\chi 2Na^+$ ions =	−13.6	$\chi 4Na^+$ ions =	−27.20
χIO_6 ions =	−52.4	χI_2O_9 ions =	−99.32
χH ions =	0	$\chi 3H_2O$ =	−38.94
$\chi_M Na_2H_3IO_6 =$	−65.84	$\chi_M Na_4I_2O_9.3H_2O =$	−165.46

It is therefore clear that sodium periodate has the formula shown above and the small difference of −4.06 being due to the depression of the bonds connecting two atoms of sodium and IO_6 ion.

* Susceptibility values are expressed in units of 10^{-6}.

Periodates of Silver

(a) *Silver mesoperiodate*, Ag_3IO_5.—It has got only one formula. Susceptibility of Ag_3IO_5 is calculated as shown below·

$\chi 3Ag$ ions	$= -75$
χIO_5 ion	$= -51.96$
Calculated Ag_3IO_5	$= -126.95$
Experiimental Ag_3IO_5	$= -123.64$

The difference between experimental and the calculated values (−3.31) is probably due to the depression caused by the bonds joining 3Ag and IO_5 ions or due to a small discrepancy in the calculated values of IO_5 ion.

(b) *Diargentous paraperiodate*, $Ag_2H_3IO_6$.—It has got two simple formulae (i) $Ag_2H_3IO_6$ (diargentous paraperiodate) and (ii) $Ag_4I_2O_9.3H_3O$ (silver dimesoperiodate).

TABLE V

Calculations of χ_M for two formulae

Calculated χ_M $Ag_2H_3IO_6$		Calculated χ_M $Ag_4I_2O_9.3H_2O$	
2Ag ions	$= -50.00$	4Ag ions	$= -100.0$
IO_5 ion	$= -52.24$	I_2O_9 ion	$= -99.32$
3H ions	$= -0$	$3H_2O$	$= -39.00$
$Ag_2H_3IO_6$	$= -102.24$	$Ag_4I_2O_9.3H_2O$	$= -238.32$

The experimental value −99.66 agrees with −102.24 for $Ag_2H_3IO_6$. As stated above the small difference of −2.58 between calculated and experimental values may be attributed to the bonds joining Ag and IO_6 ions. The difference −2.58 nearly agrees with the difference −3.31 between calculated and experimental values of Ag_3IO_5, thus lending further confirmation to these formulae.

Another important case from the structural point of view is that of lanthanum periodate which can have two simple formulae (i) $LaIO_5.2H_2O$ (dihydrated lanthanum paraperiodate) and (ii) $La_2H_2I_2O_{11}.3H_2O$ (trihydrated lanthanum mesoperiodate).

The value of I_2O_{11} ion can be derived from the experimental χ_M of $Hg_4I_2O_{11}$. Substituting the value of Hg^{++} (−37) in $Hg_4I_2O_{11}$ (−225.55) we get the value of I_2O_{11} ion $= -77.55$.

La^{+++} has 54 extranuclear electrons and just precedes the rare earth elements on the periodic table. Its spectroscopic state $^1s_0$ with values of L=0, S=0 and j=0 shows that the ion has zero or extremely weak diamagnetic moment. However, the ion shows a variation of moment with the chemical combination. In some salts such as $LaCl_3$ it behaves as paramagnetic while in others as $La_2(SO_4)_3$ it is diamagnetic. Its contribu· tion to diamagnetism is so small that it can be easily neglected,

Ignoring the ionic susceptibility contributions of La^{+++} ion, we can compare the experimental and calculated values for the two formulae of lanthanum periodate.

TABLE VI

	Formula	Obs.	Calc.	Diff.
(a)	$LaIO_5.2H_2O$	-60.76	-77.95	-17.19
(b)	$La_2H_2I_2O_{11}.3H_2O$	$-60.76 \times 2 = -121.52$	-116.55	$+4.97$

The difference in formula (ii) is small but is positive while in other periodates previously discussed it is negative, and equal to -3 or -4 units. Thus the calculated value for formula (ii) is 7 or 10 units less than expected. These 10 units may be attributed to the ionic susceptbiility of $2La^{+++}$ ions. This small contribution of La^{+++}, if considered in formula (i), would tend to increase the difference of -17.19 still further, while for the formula (ii) it would tend to bring the experimental and calculated values still closer. This lends support to the formula $La_2H_2I_2O_{11}.3H_2O$ for lanthanum periodate.

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BASIC SULPHATES OF BIVALENT METALS (Cd, Cu, Zn). PART III. ZINC

By Barun Chandra Haldar

The basic sulphates $ZnSO_4.3Zn(OH)_2$ and $ZnSO_4.Zn(OH)_2$ have been shown to exist by thermometric method.

Various basic sulphates have been described in the literature by different authors. But according to Lubkowskaia (*J. Russ. Phys. Chem. Soc.*, 1917, **39**, 989) the basic sulphate $ZnSO_4.3ZnO.3H_2O$ exists only as a definite compound. The potentiometric titrations (Nikurashiu, *J. Gen. Chem. U.S.S.R.*, 1938, **8**, 1454) of zinc sulphate solutions with alkali show the existence of the compound $ZnSO_4.3Zn(OH)_2$ or $ZnSO_4.3ZnO$. Hagisawa (*Bull. Inst. Phys. Chem. Res.*, Tokyo, 1939, **18**, 368) has stated that the potentiometric titrations of zinc sulphate solution with alkali show the existence of the compound $ZnSO_4.3Zn(OH)_2$ when the concentration of zinc sulphate is 0.0074 g. mol. per litre and the compound $Zn(OH)_2$ when zinc sulphate concentration is 0.0004955 g. mol. per litre. No indication of the basic salt $ZnSO_4.ZnO$ has been observed by the potentiometric method although literatures on the basic sulphate of zinc mention a compound of the formula $(ZnOH)_2SO_4$ (Athanasesco, *Compt. rend.*, 1886, **103**, 271) which is equivalent to $ZnSO_4.Zn(OH)_2$. Moreover, considering the similarity of Zn with Cd and Cu, it is expected that zinc will also give a basic sulphate of the formula $ZnSO_4.Zn(OH)_2$ particularly in concentrated solutions. So, here zinc sulphate solution has been titrated with caustic soda solution to see whether the indications of the two basic sulphates, $ZnSO_4.3ZnO$ and $ZnSO_4.ZnO$, as in the case of Cd and Cu, are obtained.

Experimental

The thermometric arrangement is the same as that has been described in Part I of the series (*This Journal*, 1946, **23**, 147). The reagents used were of 'Analar' quality. Standard solutions of zinc sulphate were prepared by direct weighing and standard solutions of caustic soda were prepared by standardising with potassium bi-iodate using Wesslow as an indicator

TABLE I

NaOH soln.=1.0611M. ZnSO$_4$ soln.=0.26528M, taken=40 c.c. (Fig. 1).

NaOH added.	Temp.	Rise in temp.	Total rise (in temp.)
0 c.c.	3.130°	0.000°	0.000°
1	3.080	0.100	0.100
2	2.920	0.110	0.210
3	2.810	0.110	0.320
4	2.700	0.110	0.430
5	2.500	0.100	0.530
6	2.500	0.100	0.630
7	2.410	0.090	0.720
8	2.320	0.090	0.810
9	2.220	0.100	0.910
10	2.170	0.050	0.960
11	2.120	0.050	1.010
12	2.080	0.040	1.050
13	2.055	0.025	1.075
14	2.030	0.025	1.100
15	2.010	0.020	1.120
16	2.000	0.010	1.130
18	1.980	0.020	1.150
20	1.970	0.010	1.160
22	1.950	0.020	1.180
24	1.940	0.010	1.190
26	1.920	0.020	1.210
28	1.910	0.010	1.220

TABLE II

NaOH soln.=2.0082M. ZnSO$_4$ soln.=0.20082M, taken=40 c.c. (Fig. 2).

NaOH added.	Temp.	Rise in temp.	Total rise (in temp.)
0.0 c.c.	4.605°	0.000°	0.000°
1.0	4.480	0.125	0.125
2.0	4.330	0.150	0.275
3.0	4.210	0.120	0.395
4.0	4.085	0.125	0.520
5.0	3.970	0.115	0.635
5.5	3.940	0.030	0.665
6.0	3.910	0.030	0.695
7.0	3.860	0.050	0.745
7.5	3.830	0.030	0.775
8.0	3.800	0.030	0.805
8.5	3.790	0.010	0.815
9.0	3.770	0.020	0.835
10.0	3.745	0.025	0.860
11.0	3.745	0.000	0.860
12.0	3.745	0.000	0.860
13.0	3.745	0.000	0.860
14.0	3.745	0.000	0.860
15.0	3.745	0.000	0.860

TABLE III

NaOH soln.$=1.0611M$. ZnSO$_4$ soln.$=0.13260M$, taken$=40$ c.c. (Fig. 3).

NaOH added.	Temp.	Rise in temp.	Total rise (in temp.)
0 c.c.	3.370°	0.000°	0.000°
1	3.320	0.050	0.050
2	3.250	0.070	0.120
3	3.170	0.080	0.200
4	3.090	0.080	0.280
5	3.010	0.080	0.360
5.5	2.960	0.050	0.410
6.0	2.930	0.030	0.440
6.5	2.890	0.040	0.480
7.0	2.850	0.040	0.520
8.0	2.790	0.060	0.580
8.5	2.770	0.020	0.600
9.0	2.745	0.025	0.625
9.5	2.715	0.030	0.655
10.0	2.700	0.015	0.670
11.0	2.700	0.000	0.670
12.0	2.700	0.000	0.670
13.0	2.700	0.000	0.670
14.0	2.700	0.000	0.670
15.0	2.700	0.000	0.670

TABLE IV

NaOH soln.$=0.50205M$. ZnSO$_4$ soln.$=0.050205M$, taken$=40$ c.c. (Fig. 4).

NaOH added.	Temp.	Rise in temp.	Tootal rise (in temp.)
0 c.c.	4.695°	0.000°	0.000°
1	4.655	0.040	0.040
2	4.610	0.045	0.085
3	4.565	0.045	0.130
4	4.520	0.045	0.175
5	4.480	0.040	0.215
6	4.440	0.040	0.255
7	4.425	0.015	0.270
8	4.410	0.015	0.285
9	4.400	0.010	0.295
10	4.390	0.010	0.305
11	4.380	0.010	0.315
12	4.370	0.010	0.325
13	4.360	0.010	0.335
14	4.350	0.010	0.345

TABLE V

ZnSO$_4$ soln.$=0.5M$. NaOH soln.$=0.25M$, taken$=40$ c.c. (Fig. 5).

ZnSO$_4$ added.	Temp.	Rise in temp.	Total rise (in temp.)
0 c.c.	5.550°	0.000°	0.000°
1	5.550	0.050	0.050
2	5.450	0.050	0.100
3	5.370	0.080	0.180
4	5.320	0.050	0.230
5	5.260	0.060	0.290
6	5.230	0.030	0.320
7	5.195	0.035	0.355
8	5.155	0.040	0.395
9	5.130	0.025	0.420
10	5.100	0.030	0.450
11	5.000	0.100	0.550
12	4.920	0.080	0.630
13	4.810	0.110	0.740
14	4.770	0.040	0.780
15	4.730	0.040	0.820
16	4.620	0.040	0.860
18	4.630	0.060	0.920
20	4.560	0.070	0.990

DISCUSSION

All the curves show that the basic sulphate $ZnSO_4.3Zn(OH)_2$ is formed when caustic soda solution is added to zinc sulphate solution of concentrations $0.050205M$ to $0.26528M$.

FIG. 1.

NaOH *soln. added* (c.c.).

FIG. 2.

NaOH *soln. added* (c.c).
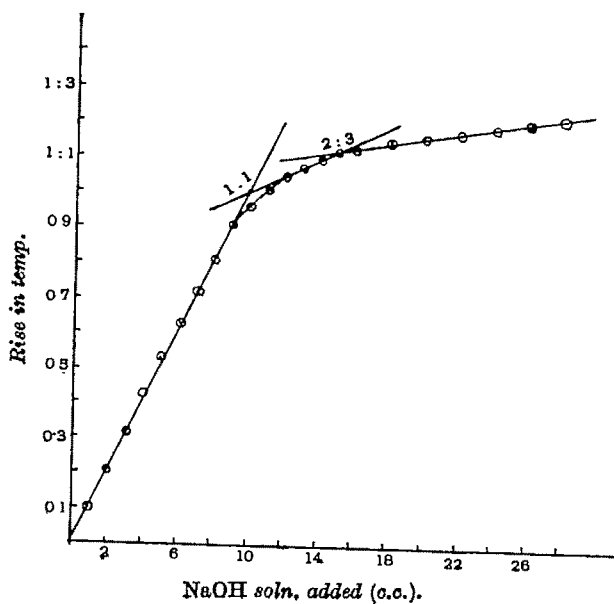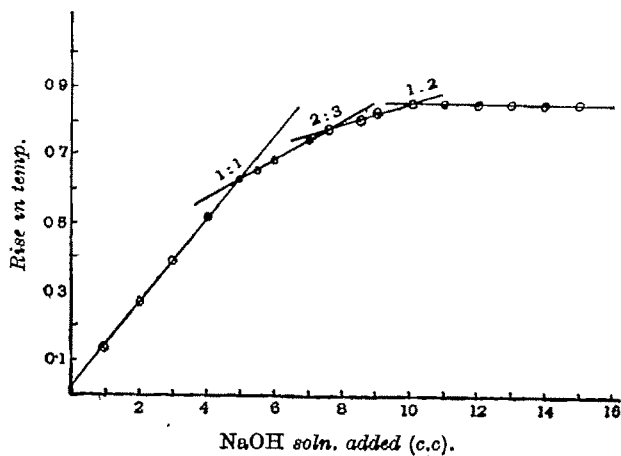
Fig. 3.
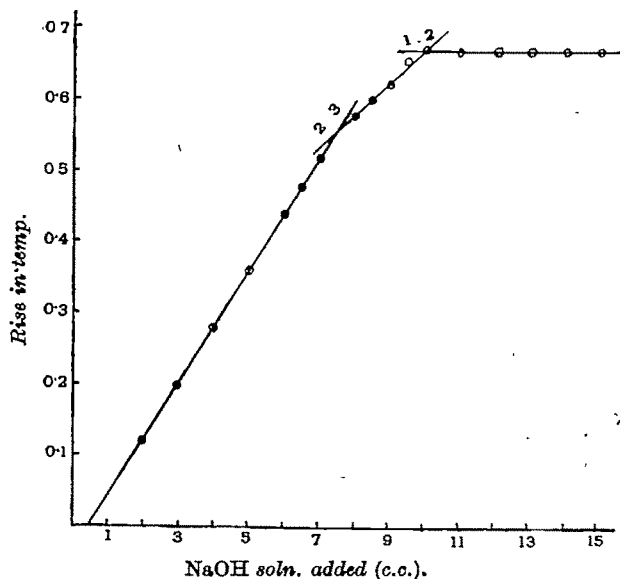
The basic sulphate $ZnSO_4.Zn(OH)_2$ is, however, first formed at concentrations $0.20082M$ and $0.26528M$, which reacts with further quantity of alkali to give the compound $ZnSO_4.$-$3Zn(OH)_2$. Again $ZnSO_4.3Zn(OH)_2$ reacts with more alkali and passes to $Zn(OH)_2$.

Fig. 4.
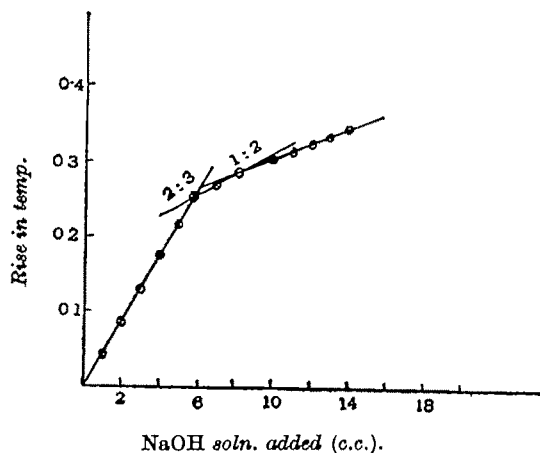
Fig. 5.
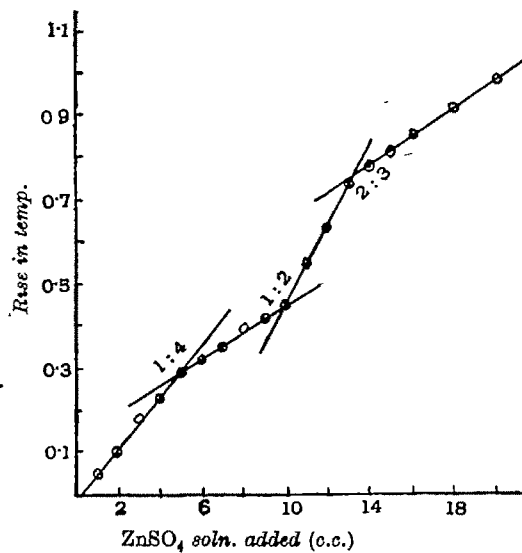
But this process is a very slow one, as is often the case with a liquid-solid reacting system. This is also evident from the curves since the break corresponding to $Zn(OH)_2$ is not observed in all the curves. The reverse titration curve *i.e.*, addition of zinc sulphate solution to alkali shows breaks corresponding to the zincate $Na_2[Zn(OH)_4]$, hydroxide $Zn(OH)_2$ and the basic sulphate $ZnSO_4.3Zn(OH)_2$. Thus the basic sulphate $ZnSO_4.-3Zn(OH)_2$ is very stable and can be obtained either by adding alkali to zinc sulphate solution or *vice versa* as in the case of Cd. The indication of the existence of the zincate $Na_2[Zn(OH)_4]$ is in conformity with the result obtained by Dutoit and Grobet (*J. chim. phys.*, 1921, **19**, 324) in the zinc-nitrate-caustic soda system.

Thus it can be concluded that Zn like Cd and Cu gives the same type of basic sulphates and shows complete similarity with Cd and Cu at least with respect to basic salt formation which may be said as the characteristic of this group (Cd, Cu and Zn) of bivalent metals.

My best thanks are due to Dr. P. B. Sarkar for his keen interest in the subject and helpful suggestions and for all laboratory facilities.

IN SEARCH FOR NEW ANALEPTIC. PART I. SYNTHESIS OF *CYCLOTETRA-METHYLENE ISOXAZOLE*

By U. P. Basu and S. P. Dhar

*cyclo*Tetramethylene *iso*xazole carboxydiethylamide has been synthesised in search for a better tolerated and a more potent analeptic.

For stimulating the respiratory and circulatory system, various analeptics, like pentamethylenetetrazole (cardiazole), diethylamide of pyridine-β-carboxylic acid (coramine), sodium camphorsulphonate amides of camphoric acid, and diethylamide of 3 : 5-dimethyl *iso*xazole-4-carboxylic acid (cycliton), pyrazine carboxylic amide, are in use. Some are good circulatory stimulant when the respiratory and circulatory mechanism is not much depressed, whereas others are better analeptic in cases of respiratory failure when there is no appreciably low blood pressure. Some are better tolerated when administered by intravenous injection and some are again more depressant than others. The analeptics are mostly heterocyclic bases with a substituted carboxyamide grouping such as found in coramine (I), or cycliton (II), and/or similar compounds containing a reduced nucleus attached to a heterocyclic ring as present in pentamethylene tetrazole (cardiazole) (III), or, certain camphor derivatives.
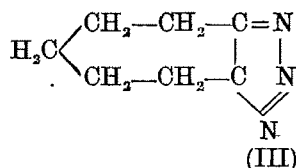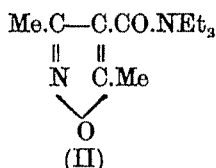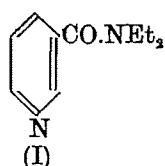
Recent observations on the development of some analeptic activity in camphoric acid amides (D.R.P. 705652) and in various *iso*xazole carboxylic amides (B.P. 451913, 466555 and 514193) seemed to be of some special interest. The ethyl derivatives of the former have been found to exhibit the maximum respiratory and circulatory analeptic properties (Goissedet and Depois, *Compt. rend.*, 1937, **205**, 1239 ; *Bull. Soc. chim.*, 1938, v, **5**, 201), and the diethylamide of 3 : 5-dimethyl-*iso*xazole-4-carboxylic acid has been noted by Reinert (*Arch. intern. pharm.*, 1937, **56**, 211) to be active in stimulating the respiration. Further 3-ethyl-4-*cyclo*hexyl-1 : 2 : 4-triazole has been found to exert a greater analeptic effect than cardiazole or coramine by Gronemeyer (*Chem. Abst.*, 1939, **82**, 5922). We have investigated compounds which might be obtained by condensing hydroxylamine with *cyclo*hexanone oxalate (IV). The *iso*xazole (V, R=Et) *via* its related acid (V, R=H) would give V(R=NEt$_2$).
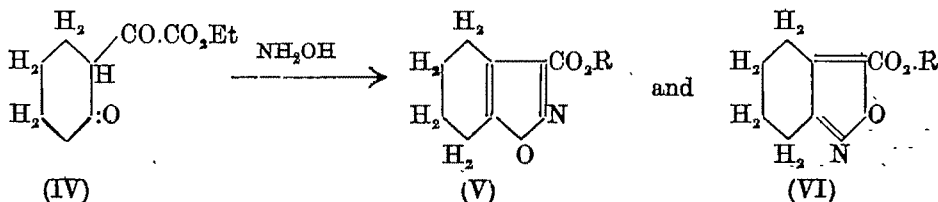
In this paper the method of preparation of the above *isoxazole* has been fully described. In course of the isolation of the *isoxazole* acid it was noticed that the compound exists in two forms pointing thereby that the hydroxylamine had reacted with both the keto groups as present in *cyclo*hexanone-2-oxalate to form two *isoxazoles* (V) and (VI) (R=Et) which had respectively given rise to 4 : 5-tetrahydrobenzo-*isoxazole*-3-carboxylic acid (V, R=H) and 3 : 4-tetrahydrobenzo-*isoxazole*-5-carboxylic acid (VI, R=H). The characteristics of the above acids as well as the pharmacological properties of their diethylamides are being studied. In order to find out whether this reaction of hydroxylamine with a diketonic carboxylate is a general one, propionyl and benzoyl acetoacetic esters have been condensed with hydroxylamine. In both cases, two isomers are isolated (*vide* experimental).

EXPERIMENTAL

Reaction of Ethyl cycloHexanone-2-oxalate with Hydroxylamine.—Ethyl *cyclo*hexanone-2-oxalate (25 g., Kötz, *Annalen*, 1925, **342**, 346) in 95% alcohol (30 c.c.) was mixed with shaking with a concentrated solution of hydroxylamine hydrochloride (18 g.) in water (20 c.c.). The mixture was left aside for 20 hours at room temperature. It was then diluted with water (100 c.c.) when an oil was obtained. The oil was extracted with ether ; the ethereal extract was dried with anhydrous sodium sulphate and ether was distilled off. The ester was distilled at 120—140°/25 mm. Repeated distillation did not afford a liquid boiling within a shorter range of temperature. Total yield was 14 g.

Hydrolysis of the above Ester.—The ester (14 g.) was heated on a water-bath for 2 hours with 100 cc. sodium hydroxide solution (10%) when the whole of the ester went into solution. The solution was cooled, and acidified with concentrated hydrochloric acid (30 c.c.). A white precipitate of the carboxylic acid was obtained. The acid on fractional crystallisation from water gave two crops one melting at 130° and another at 150°. Both fractions on analysis gave 8.5% nitrogen, 3 : 4-tetrahydrobenzo-*isoxazole*-5- carboxylic acid as well as 4 : 5-tetrahydrobenzo-*isoxazole*-3-carboxylic acid ($C_8H_9O_3N$) requires N, 8.4%.

Preparation of the Acid Chloride from the Acid (m.p. 150°).—The acid (10 g.) was dissolved in dry benzene (100 c.c.), mixed with thionyl chloride (12 g.) and refluxed on a steam-bath for 48 hours. The reaction proceeded very slowly ; when the evolution of hydrogen chloride ceased, benzene was first distilled off and the excess of thionyl chloride was driven off under diminished pressure. The oily mass left was distilled at 95 -97°/5 mm., and was obtained as a light brown oil.

Diethylamide from the above Acid Chloride.—The acid chloride (8 g.) was dissolved in dry benzene (50 c.c.) and cooled thoroughly in ice. To the cooled solution was added diethylamine (8 g.) with vigorous stirring during 2 hours. After the addition was complete, the mixture was stirred for 1 hour more. The solution was then washed with ice-water, dried over potassium carbonate and concentrated under reduced pressure when a deep brown oil was left. It was distilled and collected at 160°/10 mm. It crystallised out on cooling and long standing, and melted at 49 -50°. (Found : N, 12.71. $C_{12}H_{18}O_2N_2$ requires N, 12.6 per cent).

Diethylamide from the Acid (m.p. 130°).—The process is the same as in the above case. The excess of thionyl chloride was removed in *vacuo* and the chloride was directly used for preparing the diethylamide which was prepared as above and finally collected at 137°/10 mm. It is insoluble in water, but soluble in ordinary organic solvents. (Found : N, 12.76. $C_{12}H_{18}O_2N_2$ requires N, 12.6 per cent).

Ethylmethylethyl isoxazole-4- *carboxylate.*—Propionyl acetoacetic ester (35 g.), prepared according to the method of Bougert (*Chem. Zentrl.*, 1920, I, 28) in 35 c.c. of 95% alcohol was mixed with a concentrated solution of hydroxylamine hydrochloride (17.5 g.) in water (20 c.c.). The mixture was left at the room temperature for 20 hours. It was then diluted with water, extracted with ether and the ether extract dried over anhydrous sodium sulphate and distilled, when ethyl ester of the *iso*xazole carboxylic acid distilled at 230—40°/755 mm.

Hydrolysis of the above Ester.—The ester (25 g.) was heated on the water-bath with sodium hydroxide solution (100 c.c., 10%) for about 1½ hours when the ester went into solution, which was cooled and slowly acidified with hydrochloric acid. At p_H 4.5, a fraction was obtained, m.p. 120—22°. On lowering the p_H further, another crop was precipitated, m p. 102-104°. Both the fractions were separately crystallised from water. Both fractions on analysis gave N, 9.0 % ; 3-methyl-5-ethyl-*iso*xazole-4-carboxylic acid and 5-methyl-3-ethyl-*iso*xazole-4-carboxylic acid ($C_7H_8O_3N$) require N, 9.03 %.

Acid chloride from the Acid (m.p. 120°).—The acid (1 g.) was mixed with thionyl chloride (1 g.) and refluxed on a water-bath for about 1 hour, when a clear liquid was obtained. It was ditsilled at 220°.

Diethylamide from the acid chloride was prepared according to the general procedure in the case of other diethylamides. It was distilled at 180°/10 mm. It is soluble in alcohol, water, ether. (Found : N, 13.4. $C_{11}H_{18}O_2N_2$ requires N, 13.3 per cent).

The acid chloride from the acid (m.p. 102°) was prepared in the usual way by the action of thionyl chloride on the dry acid. It was distilled and collected at 195°.

The *diethylamide* was prepared by the action of diethylamine on the acid chloride in ether at 0°. It was collected at 167°/8 mm. It is soluble in water, alcohol and ether. (Found : N, 13.35. $C_{11}H_{18}O_2N_2$ requires N, 13.3 per cent).

Ethylphenylmethyl isoxazole-4-carboxylate.—Benzoyl acetoacetic ester (59 g.) in 95% alcohol (150 c.c.) was mixed with a concentrated solution of hydroxylamine hydrochloride (44 g.) in water (45 c.c.) and the mixture was allowed to stand at the room temperature for 24 hours. It was next diluted and extracted with ether. The ether extract was washed with excess of sodium hydroxide solution to remove unreacted benzoylacetoacetic ester, the ether removed and the ester was distilled at 210 -260°.

Hydrolysis of the Ester.—The ester (27 g.) was refluxed on a wire gauge with sodium hydroxide solution (100 c.c., 20%) for about 5 hours, when the whole of the ester went into solution. The acid was isolated in the usual manner and was fractionally crystallised from dilute alcohol (3 : 5). A fraction melting at 188-89° crystallised out first. The mother-liquor on further concentration gave out another crop melting at 140 -42°. This latter fraction was crystallised from very dilute alcohol. Both fractions on analysis gave N, 7.0%. 3-Methyl-5-phenyl- as well as 5-methyl-3- phenyl-*iso*xazole-4-carboxylic acid require N, 6.9 %.

The *acid chloride from the acid* (m.p. 188—89°) was prepared from the acid (11.5 g.) and thionyl chloride (8.8 g.). It distilled at 290°.

The *diethylamide* was prepared by treating the acid chloride (4.5 g.) in dry ether (20 c.c.) at 0° with diethylamine (1.5 g.) in dry ether (10 c.c.). The mixture was slowly treated with sodium hydroxide solution (10 c.c., 10%) and thoroughly shaken for $\frac{1}{2}$ hour. It was finally treated at 0° with 20 c.c. more of sodium hydroxide solution (10%). The ethereal layer was dried over solid potassium hydroxide and distilled. The diethylamide was collected at 210—15°/5 mm. It is insoluble in water, but soluble in alcohol and ether. (Found : N, 10.8. $C_{15}H_{18}O_2N_2$ requires N, 10.85 per cent).

The *acid chloride from the acid* (m.p. 140 -42°) boils at 265°.

The *diethylamide* from this acid chloride was prepared by the usual procedure and distilled at 185-90°/5 mm. (Found : N, 10.7. $C_{15}H_{18}O_3N_2$ requires N, 10.8 per cent).

The physiological properties of the various diethylamides of the *iso*xazole-carboxylic acids are being studied. It is interesting to note that substitution by a phenyl group renders the compound insoluble in water.

MECHANISM OF PHOSPHORYLASE ACTION

By A. K. Raichaudhury

All the available data on the equilibria in phosphorylase systems have been correlated by a new theory. It is expected that this may lead to interesting results in the study of equilibria in other reversible enzymic processes also.

Equilibria in phosphorylase systems have been studied by Cori and Cori (*J. Biol. Chem.*, 1940, **135**, 746) and Cori, Cori and Green (*ibid.*, 1943, **151**, 45) with animal phosphorylases and by Hanes (*Proc. Roy. Soc.*, 1940, **129 B**, 174) with plant enzymes. Hanes and Maskell (*Biochem. J.*, 1942, **36**, 76) by an extensive study showed that when equilibria have been attained the ratio of the similar species of ions or uncharged forms of the inorganic and organic phosphates remains constant and is independent of p_H variation. On closer examination, however, (as we shall see later on) this hypothesis did not seem to work very satisfactorily and something remained still to be desired. In what follows, we therefore propose to develop a new interpretation of the nature of phosphorylase action.

A protein ampholyte undergoes in solution on electrolytic dissociation similar to the simple amino-acids, *e.g.*

$$\text{HROH} \rightleftharpoons \text{H}^+ + \text{ROH}^- \text{ (acidic dissociation)}$$

$$\text{HROH} \rightleftharpoons \text{OH}^- + \text{HR}^+ \text{ (basic dissociation)}$$
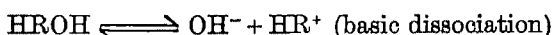
For simplicity, we shall follow the classical method of writing these equations. The modern notion (Bjerrum, *Z. physikal. Chem.*, 1923, **104**, 147) contending that the ampholyte exists not as HROH but mainly as R^{+-}, leads to the same results but only from different lines of approach (Glasstone, "The Electro-chemistry of Solutions", 1930, p. 247).

Returning to the dissociation equations, as p_H increases, the basic dissociation is suppressed, while the acidic dissociation is facilitated. In the acidic regions near about the neutral ($p_H 7$) and for the proteins, which have their iso-electric points also in the neighbourhood of these regions, the prevalent forms would be HROH and ROH$^-$, the former predominating near the iso-electric zone.

The above ideas, of course, apply to the case of enzymes which are proteins.

The following assumption is then made :—

That the direct reaction, polysaccharide + inorganic phosphate→glucose-*l*-phosphate, is accelerated by the negative ions ROH$^-$, while the reverse by the uncharged particles R^{+-} (or HROH).

It may be noted here that the idea of only particular portions of the enzyme being catalytically active is not new (Goodwin and Hanger, *Proc. Soc. Exp. Biol. & Med.*, 1926, **23**, 261 ; Northrop, *J. Gen. Physiol.*, 1925, **7**, 603).

The exact mechanism of catalysis may or may not be through an enzyme—substrate complex (Michaelis and Menton, *Biochem. Z.*, 1913, **49**, 333) but may also take place in a way similar to that suggested by Stearn (*J. Gen. Physiol.*, 1935, **18**, 301) *e.g.*, through a preliminary activation process based on the approach of a dipole (or a charge) on a large molecule like an enzyme to the reacting molecules with a resulting change in the configuration and consequently in the energy of activation.

The whole process may be visualised in our case as follows : The starch or rather the polysaccharide molecules arrange themselves evenly round the enzyme molecules ; of the total number of polysaccharide molecules, however, only an active portion, with energy greater than the activation energy E, can react with the phosphate molecules and give rise to glucose-l-phosphate. Similarly only active fractions of glucose-l-phosphate can decompose. Hence if γ (starch)=(active starch) and γ_1 (glucose-l-phosphate)= (active glucose-l-phosphate)
then according to the mass law

γ (starch).(phosphate)^n/$\gamma_1{}^n$(glucose-l-phosphate)$^n_{\ \ }=K$

Since the full chemical equation is,

starch + n.inorg.phosphate $\rightleftharpoons$ $n$glucose-l-phosphate.

Let,
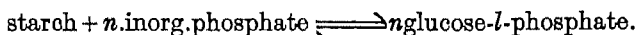
α=fraction of the total number of enzyme molecules that are in the form HROH.

β=fraction of the total number of molecules of the enzyme that are in the form ROH$^-$.

C=(polysaccharide) in moles/litre.

F=(inorg.phosphate) ,,   ,,

P=(organic phosphate)   ,,

[C may well refer to the " phase of the colloidal system in which the reaction occurs " and which " is maintained in a state of saturation in respect to a form of starch in true solution " (Hanes, *loc. cit.*)].

Now, the total concentration of polysaccharide molecules associated with the fraction of enzyme molecules that are in the state ROH$^-$ is $\sim \beta C$; of this only a fraction, which has an energy greater than the activation energy E, will decompose ; hence the active concentration of the polysaccharide is $\beta C e^{-E/RT}$; so that $\gamma = \beta e^{-E/RT}$; similarly the active concentration of glucose-l-phosphate is $\alpha P e^{-E_1/RT}$ and the equilibrium constant K is given by

$$K = \frac{\beta C e^{-E/RT}.F^n}{(\alpha e^{-E_1/RT}.P)^n}$$

or at constant temperature,

$$\frac{\alpha}{\beta^{1/n}} . K_0 = F/P \quad (K_0 \text{including all terms which are const. at const. temp.})$$

Now, differentiating with respect to the $[H^+]$

$$\frac{d(F/P)}{d[H]^+} = K_0 \left\{ \beta^{-1/n} \cdot \frac{d\alpha}{d[H^+]} - \frac{\alpha}{n} \frac{1}{\beta^{(n+1)/n}} \cdot \frac{d\beta}{d[H^+]} \right\}$$

$$= K_0 \left\{ \frac{1}{\beta^{1/n}} \cdot \frac{d\alpha}{d[H^+]} - \frac{\alpha}{n\beta} \cdot \frac{d\beta}{d[H^+]} \right\} \qquad \ldots \ (1)$$

(since n is very large $(n+1)/n = 1$).

This expression can be integrated in the region of p_H close to the iso-electric zone; for near the iso-electric zone, the number of charged particles is at a minimum and α has a maximum value, or,

$$\frac{d\alpha}{d[H^+]} = 0$$

hence

$$\frac{d(F/P)}{d[H^+]} = - K_0 \cdot \frac{\alpha}{n\beta} \cdot \frac{d\beta}{d[H^+]} \qquad \ldots \ (2)$$

But $$\frac{d\beta}{d[H^+]} \neq 0,$$

for β continues to increase (unlike α) with p_H. [It may be argued that the iso-electric p_H for proteins are rather sharp and our deductions will be valid only over a very limited range. But it is possible that as we move to higher p_H values, a net negative charge develops without change in the number of dipoles (*cf.* Cannan, *Cold Spring Harb. Symp. on Quant. Biol.*, 1938, **6**, 7)]. In order to evaluate the expression (2), we consider the dissociation of the enzyme as a weak acid :

$$HROH \rightleftharpoons ROH^{-1(l)} + lH^+$$

i.e. l g. ions of H^+ are produced from 1 mole of the protein, hence the charge on the anion part of the protein is also l units. l is an average value which remains approximately constant as the p_H changes in the regions we are concerned with.

[It has been shown by Cannan (*Cold Spring Harb. Symp. on Quant. Biol.*, 1938, **6**, 2) that in the region of p_H from 5 to 9, the number of equivalents of H^+ dissociated from unit weight of iso-electric protein remains almost constant (*cf.* Cohn, *ibid*, 1938, **6**, 12)].

Hence, applying the mass law and if K_d is the dissociation constant

$$K_d = (ROH)^- \cdot (H^+)^l / (HROH)$$

Now, since β is small in the acidic regions due to the depressing action of the H^+ ions, (HROH) may be regarded as remaining constant and β would be $= (ROH^-)/(HROH)$.
Therefore, $\qquad K_d = \beta (H^+)^l$. $\qquad\qquad \ldots \qquad\qquad \ldots \ (3)$
From equation (3) by taking logarithmic differential,

$$0 = \frac{1}{\beta} \cdot \frac{d\beta}{d[H^+]} + \frac{l}{[H^+]}$$

or,

$$\frac{1}{\beta} \cdot \frac{d\beta}{d[H^+]} = - \frac{l}{[H^+]} \qquad\qquad \ldots \qquad\qquad \ldots \ (4)$$

which being substituted in equation (2) gives

$$\frac{d(F/P)}{d[\mathrm{H^+}]} = +K_0 \frac{\alpha}{n} \cdot \frac{l}{[\mathrm{H^+}]} \qquad \dots (5)$$

which on integration, again, gives

$$\int d(F/P) = K_0 \frac{\alpha}{n} \cdot l \int \frac{1}{[\mathrm{H^+}]} \cdot d[\mathrm{H^+}]$$

$$F/P = K_s \cdot \log [\mathrm{H^+}] + A$$

(A is the integration constant and K_s is a composite constant)

$$= -K_s \cdot p_\mathrm{H} + A \qquad \dots (6)$$

One point of interest is worth mentioning here; Kiessling's observation (*Biochem. Z.*, 1939, 302, 50) that two different enzymes may catalyse the direct and reverse reactions selectively (which has been proved untenable by subsequent workers) does not come in conflict with ours. According to the present hypothesis different ionic forms of the same enzyme act as catalysing agents selectively for the direct and reverse reactions.

Fig. 1.
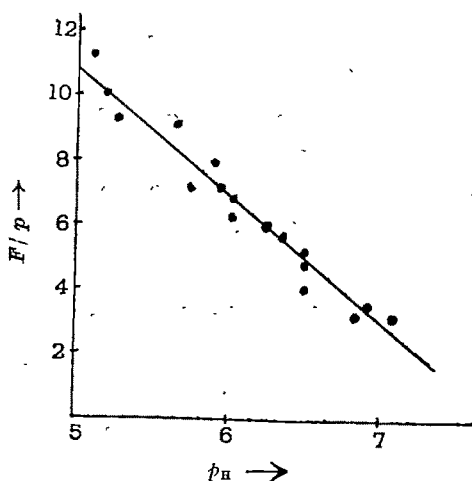
Fig. 2.
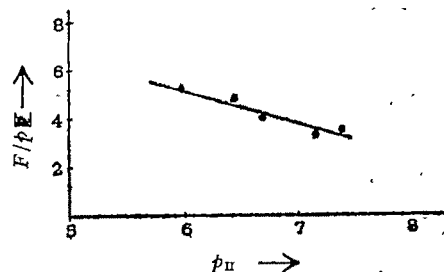
From equation (6), it follows that K_s will include l (the number of $\mathrm{H^+}$ equivalents dissociated from the enzyme molecule) and also n (the number of glucose residues in the polysaccharide). Hence the equilibrium F/P value will be dependent both on the nature (presumably the source also) of the enzyme and the polysaccharide substrate. It is also clear that F/P will be independent of the total enzyme concentration, since this does not come up in the equation; and that if F/P is plotted against p_H, a straight line would be obtained with a slope $\theta = \tan^{-1}(-K_s)$ which would be characteristic for a particular enzyme with a definite substrate. The points of the graphs are taken from Hanes and Maskell (*loc. cit.*). In Fig. 1 (starch + inorg. phosphate ⇌ glucose-*l*-phosphate with potato phosphorylase), it will be found that the points are all distributed evenly on either side of the straight line. In cases of brain and liver enzymes (Fig. 2 and 3) also satisfactory straight lines are obtained. The case of muscle phosphorylase is, however, of interest.

Curve A in Fig. 4 represents the reaction glycogen+inorganic phosphate → glucose-l-phosphate ; Curve B in Fig. 4 shows the reverse reaction glucose-l-phosphate → glycogen (?)+inorg. phosphate. It would be noticed that (unlike the cases with other enzymes) the points on the straight line in Fig. 4, Curve A are almost always higher than the

Fig. 3.
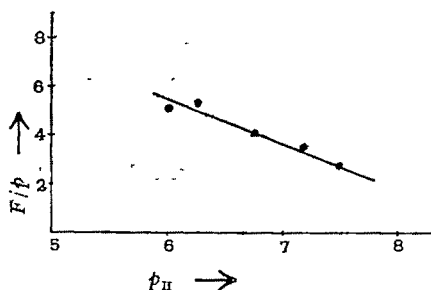
Fig. 4.
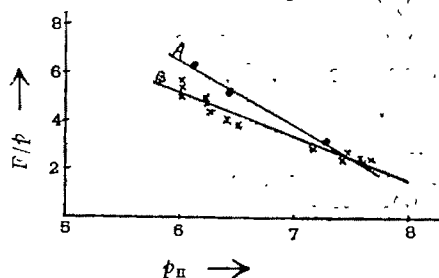
corresponding points on the Fig. 4, Curve B representing the reverse reaction. This, however, is not to be expected if a state of true equilibrium obtains in this system, for then the same final state would have been reached from whichever side we approach it. Further, the fact that glucose-l-phosphate *in vitro* gives rise with muscle phosphorylse to a product which is identical with starch in iodine colouration, X-ray diffraction pattern and also in having an unbranched structure (Hassid, Cori and McCready, *J. Biol. Chem.*, 1943, **148**, 89), prejudices against any idea of true equilibrium being attained in a system containing glycogen, inorg. phosphate and muscle phosphorylase. Thus, it is quite probable that a simple equilibrium such as glycogen+inorg. phosphate $\rightleftharpoons$ glucose-l-phosphate with muscle phosphorylase does not exist.

We have already seen that hitherto the equilibrium in these phosphorylase systems has been assumed to be governed by the constancy of the ratio of the divalent ions HPO_4''/RPO_4'' etc. of the two acids, phosphoric and glucose-l-phosphoric. Hanes' scheme (*cf.* Parnas, *Ergebn.Enzymforsch.*, 1937, **6**, 57) was as follows :—

$$Starch + HPO_4'' \rightleftharpoons RPO_4'' \quad (R = glucose\ part)$$

$$H^+ \Updownarrow \qquad H^+ \Updownarrow$$

$$H_2PO_4' \qquad RHPO_4'$$
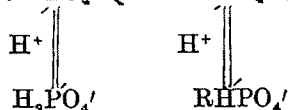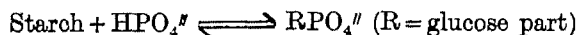
The effect of the variation of p_H was supposed to be due to its influence on the dissociation of the two acids. Since glucose-l-phosphoric is the stronger acid, increase in p_H favoured its formation. Although this hypothesis works fairly well with potato enzyme, it fails practically completely in the case of animal enzymes, because

(a) the ratio of the divalent ions HPO_4''/RPO_4'' can hardly be said to be satisfactorily constant :

(b) the ratio of the monovalent ions show still greater divergence ;

(c) Still more serious is the fact that this latter ratio shows statistically significant and systematic variation with p_H. Hanes and Maskell (*loc. cit.*) themselves doubted the validity of the above hypothesis in the case of animal enzymes at least ;

(*d*) No cognizance has been taken of the specific enzyme effect.
With different phosphorylases a slight variation in the equilibrium point is always found even with identical substrates.

Thus, there appears to be no other mechanism in the literature which can knit up the whole available data (both plant and animals) in a clean and systematic way.

In conclusion, I beg to offer my grateful thanks to Dr. D. M. Bose, the Director, for criticism, advice and interest in this work.

The author is also indebted to Prof. A. Maitra for advice and elucidation of some points and to Dr. B. N. Ghosh but for whose help the work could not have been completed.

STUDIES IN FRIES MIGRATION. PART I. THE FRIES MIGRATION OF ESTERS OF 7-HYDROXY-4-METHYLCOUMARIN

By V. M. Thakor and N. M. Shah

Little systematic work has been done on the Fries migration of the hydroxy-esters of the coumarins. The work described in this paper was therefore undertaken and 7-acetoxy-and 7-benzoyloxy-4-methylcoumarins have been subjected to the Fries migration with a view to investigating the effect of various factors on the migration. The results show that (*i*) three mols. of AlCl₃ are necessary to effect the migration, (*ii*) nitrobenzene as a solvent facilitates the reaction with better yields, (*iii*) the change in the conditions of the migration fails to effect the direction of the migrating group, which predominantly occupies the '8' position of the coumarin nucleus, and (*iv*) the benzoyl group requires a higher temperature for migration.

Since its discovery in 1909, the Fries migration has been extensively employed with the esters of mono- and poly-hydroxy phenols (*i*) as a method for the preparation of phenolic ketones and (*ii*) with a view to investigating its mechanism (Blatt, *Chem. Rev.*, 1940, 27, 418). Little systematic work appears to have been done on the Fries isomerisation of hydroxycoumarin esters, though during the last few years, it has been extended to this series by several workers.

Limaye and his co-workers (*Ber.*, 1932, **65**, 375 ; 1934, **67**, 12 ; *Rasayanam*, 1936, 20 ; 1937, 93 ; 1938, 141 ; 1939, 187) have carried out the Fries migration of various esters of 7-hydroxycoumarin derivatives and in all cases, obtained predominently the 8-acyl-coumarin derivatives, in some few cases accompanied with traces of the 6-acyl isomer.
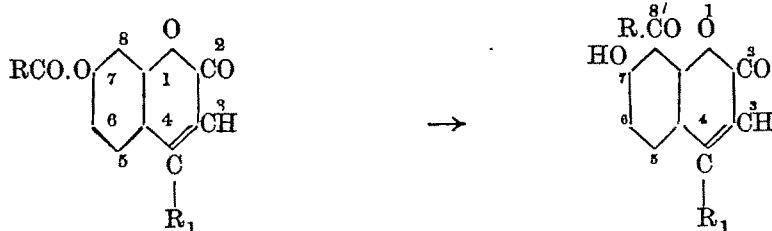
In 5-hydroxycoumarin series, different esters on being subjected to the Fries reaction gave 5-hydroxy-6-acyl-coumarin derivatives (Sethna, Shah and Shah, *J. Chem. Soc.*, 1938, 228 ; Shah and Shah, *ibid.*, 1938, 1424 ; Deliwala and Shah, *ibid.*, 1939, 1250). Desai and Mavani (*Proc. Indian Acad. Sci.*, 1942, **15A**, 1, 10) were unsuccessful in effecting the Fries migration of 6-acetoxy-4-methylcoumarin. Shah and Shah (*J. Indian Chem. Soc.*, 1942, **19**, 481) could successfully effect the Fries migration of ethyl 7-acetoxy-4-methylcoumarin-3-acetate and obtained 7-hydroxy-8-acetyl-4-methylcoumarin-3-acetic acid. All the above transformations were carried out mainly for the preparation of the specific compounds.

It is well known that in Fries migration, the position, relative to the hydroxyl group, which will be occupied by the migrating acyl group depends upon (*i*) the temperature at which the reaction is carried out, (*ii*) the nature of the acyl group and (*iii*) the phenol. The varying amounts of the migrating agent as well as the use of the solvent also influence the course of the reaction. No systematic work appears to have been done so far to

investigate the influence of these factors on the Fries migration of esters of hydroxy-coumarins.

The present investigation was therefore undertaken to study the influence of the above factors on the course of the Fries reaction ; acetyl and benzoyl derivatives of 7-hydroxy-4-methylcoumarin were selected for the purpose.

Effect of Aluminium Chloride.—The amount of the migrating agent is known to have a considerable effect on the migration (Ralston *et al.*, *J. Org. Chem.*, 1940, **5**, 645). Our observations also support this. With less than three moles of aluminium chloride, the product was exclusively 7-hydroxy-4-methylcoumarin in case of the acetxoy derivative, while some unreacted ester was recovered in case of the benzoyloxy derivative, along with the debenzoylated product and no migration product could be isolated. This clearly shows that at least three molecules of aluminium chloride are required for the acyl group to migrate ; while with less amount of the same, only the cleavage product is formed.

It is well known that aluminium chloride forms addition complexes with compounds containing oxygen (Thomas, "Aluminium Chloride in Organic Chemistry", pp. 48-54). Since in coumarin there are O and CO in '1' and '2' positions, which can form complexes, it is probable that 2 moles are utilised in the complex formation. If such a complex formation takes place, no reaction will be effected till aluminium chloride is equal to or less than two moles and will be complete only if the amount is three moles.

Effect of Temperature.—Numerous workers (Eikmann, *Chem. Weekblad*, 1904, **1**, 453 ; 1905, **2**, 59, 79 ; Rosenmund and Schnurr, *Annalen*, 1928, **460**, 56) have observed the influence of temperature on the Fries reaction ; low temperature favouring the *para* migration, while the higher temperature, leading to the *ortho* migration. In this investigation, the *para* migration is not possible, but there are two *ortho* positions favourable and the different conditions may direct the groups differently. We find that no migration takes place at room temperature and the migration increases with the rise in temperature. A temperature as high as 130-140° is necessary for complete migration, the acyl group predominently occupying the 8-position of the coumarin nucleus.

It is clear that the change in temperature has no influence on the position taken up by the acyl group. Further, the increase of temperature has little effect when the amount of aluminium chloride is less than 3 moles. It was also observed that actually the reaction is over within 15 to 20 minutes, because the evolution of HCl gas was vigorous during that period after which it slowed down.

Influence of Solvent.—Literature shows conflicting views about the role played by a solvent in determining the course of the reaction. Some think that the solvent may effect the ease and extent of the reaction but has little effect in directing the migration in a particular position (Baltzly and Bass, *J. Amer. Chem. Soc.*, 1933, **55**, 4292 ; Fieser and Bradsher, *ibid.*, 1936, **58**, 1738, 2337) ; others are of the opinion that solvent has profound influence (Ralston *et al*, *loc. cit.*). We found that nitrobenzene as solvent had made the reaction smooth and rapid with an improvement in the yield of the product. However, it had little effect when aluminium chloride was less than 3 moles, nor did it exert any influence in directing the migrating group.

Nature of the Acyl group.—That the rate of migration varied with different acyl groups has long been observed (Rosenmund and Schnurr, *loc. cit.* ; Baltzly and Bass,

loc. cit.). We find that the acetyl group is easily split off the oxygen atom while the benzoyl is rather firmly held. Further, the benzoyl group requires a higher temperature for migration than the acetyl group.

In all cases, it was observed that the main product of the Fries reaction was 7-hydroxy-4-methyl-8-acyl-coumarin, a trace of 6-acyl isomer being obtained in the case of the acetyl derivative and that only in few cases. The benzoyl derivative gave in no case the 6-benzoyl derivative even in a trace. The change of conditions failed to change the course of the reaction, proving that the ' 8 ' position is more reactive than ' 6.' This reactivity can be explained on the theory of ' Fixation of Double Bonds ' first advanced by Mills and Nixon (*J. Chem. Soc.*, 1930, 2510). The migrating group attaches to that C atom which is bound by a double bond with the C atom bearing the hydroxyl group.

EXPERIMENTAL

7-Acetoxy- and 7-benzoyloxy-4-methylcoumarins were prepared according to Pechmann and Duisberg from β-methylumbelliferrone (*Ber.*, 1883, **16**, 2124).

General Method of carrying out the Fries Migration. (*i*) *In Nitrobenzene as a Solvent.*—The ester was dissolved in the dry solvent ; a solution of anhydrous aluminium chloride in the same solvent was added. The mixture protected from moisture (CaCl$_2$-guard tube) was left at room temperature or heated to the required temperature for a definite period. It was then decomposed by ice and HCl. Nitrobenzene was removed by steam distillation. The residual solid, if any, as well as the product obtained on cooling the liquid, were examined.

(*ii*) *Without a Solvent.*—The powdered ester was intimately mixed with aluminium chloride and the mixture heated to the required temperature for a definite period. It was then cooled ; ice and HCl added and the solid obtained investigated.

The results of the various experiments are tabulated for the sake of brevity. In all the experiments, the reaction was carried out with 4.5 g. of coumarin ester for the sake of uniformity. Table I describes the Fries migration of the acetyl derivative and Table II describes the Fries migration of the benzoyl derivative under different conditions.

TABLE I

Fries migration of 7-acetoxy-4-methylcoumarin

	Solvent.	Temp.	Time.	Amount of AlCl$_3$ (in moles)	Deacetylated 7-hydroxy-4-methyl-coumarin	Product-7-Hydroxy-8-acetyl-4-methyl-coumarin (in g.)	7-Hydroxy-6-acetyl-4-methyl-coumarin (in g.)
1	Nitrobenzene (60 c.c.)	25-27°	24 hr.	3.3	2.5 g.	Indication	..
2	,, (30 c.c.)	70°	6	1.1	3.0	..	..
3	,, (60 c.c.)	,,	6	3.3	2.5	Traces	..
4	,, (30 c.c.)	100	4	1.1	3.0	..	..
5	,, (60 c.c.)	,,	4	3.3	2.0	0.5	..
6	,, (30 c.c.)	130-40°	1	1.1	3.0	..	..
7	,, (60 c.c.)	,,	1	3.3	0.2	3.0	Traces
8	No solvent	,,	1	1.1	3.0	..	..
9	,,	,,	1	2.2	3.0	..	..
10	,,	,,	1	3.3	0.5	2.5	Traces
11	Nitrobenzene (30 c.c.)	25-27°	24	1.1	3.0	..	..
12	,, (50 c.c)	,,	24	2.2	3 0	..	..

1. No unreacted ester was recovered.
2. Amount of AlCl$_3$ used was 10% excess to account for inert ingredients

6—1607P—5

TABLE II

Fries migration of 7-benzoyloxy-4-methylcoumarin

	Solvent.	Temp.	Time	Amount of $AlCl_3$ (in moles)	Unreacted 7-benzoyloxy 4-methyl-coumarin	Debenzoylated 7-hydroxy-4-methyl-coumarin	7-Hydroxy-4-methyl-8-benzoyl-coumarin
					2.5 g.		
1	Nitrobenzene (60 c.c.)	25-27°	24 hrs.	3.3		0.8g.	..
2	,, (60 c.c.)	70	6	3.3	2.0	1.2	Indication
3	,, (60 c.c.)	100	4	3.3	1.5	1.0	0.5g.
4	,, (30 c.c.)	130-40	1	1.1	2.0	1.0	..
5	,, (60 c.c.)	,,	1	3.3	1.0	0.5	1.5
6	No solvent	,,	1	3.3	1.2	0.7	1.0
7	Nitrobenzene (30 c.c.)	150-60	1	1.1	1.2	1.5	..
8	,, (60 c.c.)	,,	1	3.3	..	0.2	3.0
9	No solvent	,,	1	1.1	2.0	1.0	..
10	,,	,,	1	3.3	..	0.4	2.5
11	Nitrobenzene (30 c.c.)	25-27	24	1.1	2.5	0.7	..
12	,, (30 c.c.)	70	6	1.1	2.2	1.0	..

1. No 7-hydroxy-4-methyl-6-benzoylcoumarin could be isolated.

2. 7-Hydroxy-4-methyl-8-benzoylcoumarin gives dark red colouration with alcoholic ferric chloride characteristic of the compounds with -OH and -CO.R groups in *ortho*-positions. Limaye (*Ber.*, 1934, 67, 12 ; *Rasayanam*, 1937, 80) mentions that this compound does not give colouration with ferric chloride. This is probably due to the fact that this compound is sparingly soluble in alcohol.

The authors thank Dr. R. C. Shah, Dr. G. V. Jadhav and Dr. S. M. Sethna for their interest in the investigation.

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STUDIES ON SULPHONAMIDES AND ANALOGOUS COMPOUNDS. PART II.

BY J. SIKDAR

A number of p-amino- and p-aminomethylbenzene sulphone derivatives has been prepared.

The observation of Klarer (*Klin. Wochsch.*, 1941, **20**, 1250) that p-aminomethyl-benzene sulphonamide is effective against anaerobic clostridia associated with war-wound infections, has opened up a new field for chemotherapy in bacterial infections. Unlike the common sulphonamide derivatives it is not affected by the presence of p-amino-benzoic acid (*cf.* Schreus, *Klin. Wochsch.*, 1942, **21**, 671 ; Basu, Sen and Sikdar, *Science & Culture*, 1944-45, **10**, 262). These observations and the recent findings (Bambas, *J. Amer. Chem. Soc.*, 1945, **67**, 668, 671) that certain sulphones exert a chemotherapeutic action against pulmonary tuberculosis in animals, stimulated an interest in the search for some simple sulphones of the types (I) and (II), mainly with a view to studying the differences in their physiological and pharmacological actions against various aerobic as well as anaerobic organisms in presence of p-aminobenzoic acid.

$$NH_2.C_6H_4SO_2.R \qquad NH_2.CH_2.C_6H_4SO_2.R$$
$$(I) \qquad\qquad (II)$$
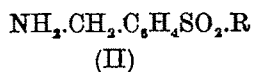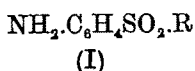
The work is in progress, but as a paper on polymethylene-*bis*-(p-aminophenylsulphones) has been just published by Cutter, Danielson and Golden (*J. Amer. Chem. Soc.*, 1945, **67**, 1051), the preparation and the properties of the compounds that have been so far studied in this laboratory are being recorded in the body of this paper (*cf.* Sikdar and Basu, *J. Indian Chem. Soc.*, 1945, **22**, 343).

The sulphones were generally prepared by the action of the sodium salt of p-acet-amidobenzene sulphinic acid, prepared from the corresponding sulphonyl chlorides on the appropriate haloid compound in alcoholic suspension followed by hydrolysis of the resulting acetamido compound to the free amines. The reactions involved may be illustrated as follows :—

$$Me.CONH.C_6H_4SO_2Cl \longrightarrow MeCONH.C_6H_4SO_2Na$$
$$\Big\downarrow XR'$$
$$NH_2C_6H_4SO_2.R' \xleftarrow{H_2O} Me.CONH.C_6H_4SO_2.R'$$
$$(\text{where } X=Cl \text{ or } Br.)$$
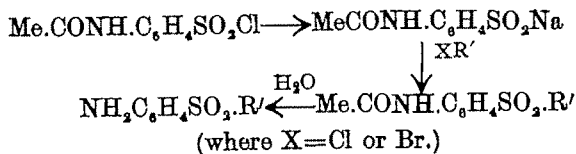
In cases of p-aminomethylbenzene sulphone compounds the starting materials were again the p-acetamidomethylbenzene sulphonyl chloride, prepared by the action of chloro-sulphonic acid on acetylbenzylamine according to a method similar to that of Smiles and Stewart (*cf.* "Organic Synthesis", Vol, V, p. 2).

EXPERIMENTAL

Preparation of Sulphinate.—The acetyl derivative of the sulphinic acid was prepared by reducing the corresponding sulphonyl chloride with sodium sulphite in a slightly alkaline solution, filtering and acidifying the filtrate with concentrated sulphuric acid. The acid was then converted into its sodium salt by adding requisite amount of sodium bicarbonate in aqueous suspension. The solution obtained was filtered and concentrated to get the sodium salt used in the following preparations.

Preparation of Acetaminosulphone Derivatives.—Equimolecular proportions of acetamino- or acetaminomethylphenyl sodium sulphinate and the mono-haloid deriva-

tives (e.g., benzyl chloride, chloroacetone and allyl bromide) were dissolved in alcohol (95%) and the mixtures were refluxed for 5 to 6 hours in a boiling water-bath. The reaction mixture was then filtered, and the filtrate on cooling, concentration or evaporation afforded the sulphone derivative. This was crystallised from dilute alcohol.

In case of the ethylene-*bis*-sulphone derivatives one molecule of ethylene dibromide was treated with two molecules of the sodium salt of the sulphinic acid derivative and the final product was crystallised from dilute acetic acid.

Hydrolysis.—In order to obtain the free sulphone the above acetylated product (one part) was hydrolysed by refluxing with 10% hydrochloric acid (25-30 parts) for about 4 to 6 hours. The hydrolysed solution was generally treated with charcoal, filtered and the filtrate on concentration afforded the sulphone in shining crystals. These sulphones are almost insoluble in water, but readily dissolve in alcohol. The aminomethylphenyl sulphones were isolated in the form of their hydrochlorides, and these are readily soluble in water.

The different compounds prepared, their melting points and analyses are being recorded in the following table.

<div align="center">TABLE I</div>

Compound.	M.p. (uncorr)	Formula.	Calculated N.	Calculated S.	Found N.	Found S.
4-Acetaminophenyl-benzyl sulphone	180°	$C_{15}H_{15}O_3NS$	4.84%		4.97%	
4-Aminophenyl-benzyl sulphone	216-17°	$C_{13}H_{13}O_2NS$	5.66	12.95%	5.73	12.89%
4-Acetaminophenyl-acetonyl sulphone	115°	$C_{11}H_{13}O_4NS$	5.49		5.67	
4-Aminophenyl-acetonyl sulphone	135°	$C_9H_{11}O_3NS$	6.57	15.02	6.69	15.07
4-Acetaminophenyl-allyl sulphone	98-100°	$C_{11}H_{13}O_3NS$	5.85		6.04	
4-Aminophenyl allyl-sulphone	106°	$C_9H_{11}O_2NS$	7.1		7.28	
4-Acetaminomethyl-phenyl acetonyl sulphone	143-44°	$C_{12}H_{15}O_4NS$	5.21		5.48	
4-Aminomethyl phenyl acetonyl sulphone hydrochloride	208° (decomp.)	$C_{10}H_{14}O_3NSCl$	5.31	(Cl) 13.47	5.46	(Cl) 12.77
Ethylene-*bis*-(4-acet-aminophenyl-sulphone)	292°* (decomp.)	$C_{18}H_{20}O_6N_2S_2$	6.60		6.75	
Ethylene-*bis*-(4-amino-phenyl sulphone)	336°** (decomp.)	$C_{14}H_{16}O_4N_2S_2$	8.23		8.36	
Ethylene-*bis*-(4-aceta-mino methylphenyl sulphone)	264°.	$C_{20}H_{24}O_6N_2S_2$	6.22		6.11	
Ethylene-*bis*-(4-amino methylphenyl sulphone dihydrochloride	320° (char.)	$C_{16}H_{22}O_4N_2S_2Cl_2$	6.35	(Cl) 16.1	6.46	(Cl) 16.03

* Cutter *et al* (*loc. cit.*) recorded 284-285° (decomp.) ;
**   ,,   ,,   ,,   328-330° (decomp.).

The author wishes to express his sincere thanks to Dr. U. P. Basu for his interest in this investigation.

STUDIES ON CADMIUM IODIDE COMPLEXES

By Barun Chandra Haldar

The complex formation of cadmium iodide by the thermometric method has been studied. From the breaks in the curves it is inferred that the complex ions CdI_4'' and CdI_5''' exist in solution.

The peculiar behaviour of cadmium iodide in cryoscopy and conductivity indicates the auto-complex formation in solution (Wienland, "Einfuhrung in die Chemie der complex-verbindungen," Stuttgart, 1924, p. 423). Molecular conductivity at dilution $v=128$ shows it to be a two-ion compound, although at higher dilutions it behaves as a three-ion compound. Hittorf (*Pogg. Ann.*, 1859, **106**, 526) from the transport experiment in water solution concluded that cadmium iodide is the cadmium salt of the complex hydro-cadmi-iodic acid $H_2(CdI_4)$. According to McBain (*Z. Elektrochem.*, 1905, 11, 215) in concentrated solutions, the ions Cd^{++} and CdI_3' and in dilute solutions, the ions Cd^{++} and I' exist. It has been found from the boiling and freezing point experiments that the observed molecular weight of cadmium iodide is normal *i.e.*, calculated molecular weight 366.27. This can, however, be explained by both the formulae $Cd(CdI_3)_2$ and $Cd(CdI_4)$. In order to distinguish whether either of the complexes is present or both in solution the author has employed thermometric titration (CdI_2 and KI; $CdSO_4$ and KI) method which is one of the most sensitive physical methods so far known.

Experimental.

The thermometric arrangement is the same as that has been described in a previous paper of the author (*J. Indian Chem. Soc.*, 1943, 23, 147). The reagents used were of 'Analar' quality. Standard solutions were prepared by direct weighing and they were further checked by estimating cadmium as $CdNH_4PO_4$, H_2O and iodide with silver nitrate volumetrically.

TABLE I

KI soln.=5*M*. CdI_2 soln.=0.5*M*, taken=40 c.c. (Fig. 1).

KI added,	Temp.	Diff. in temp.	Total diff (in temp.)
0 c.c.	2.720°	0.000°	0.000°
1	2.670	0.050	0.050
2	2.610	0.060	0.110
3	2.530	0.060	0.170
4	2.490	0.060	0.230
5	2.425	0.065	0.295
6	2.360	0.065	0.360
7	2.300	0.060	0.420
8	2.250	0.050	0.470
9	2.230	0.020	0.490
10	2.230	0.000	0.490
11	2.230	0.000	0.490
12	2.240	—0.010	0.480
13	2.275	—0.035	0.445
14	2.310	—0.035	0.410
15	2.345	—0.035	0.375
16	2.380	—0.035	0.340
18	2.450	—0.070	0.270

Table II

KI soln.$=4.762M$. CdI$_2$ soln.$=0.25M$, taken$=40$ c.c. (Fig. 2).

KI added.	Temp.	Diff. in temp.	Total diff. (in temp.)
0 c.c.	2.945°	0.000°	0.000°
1	2.920	0.025	0.025
2	2.880	0.040	0.065
3	2.840	0.040	0.105
4	2.800	0.040	0.145
4.5	2.790	0.010	0.155
5.0	2.790	0.000	0.155
5.5	2.790	0.000	0.155
6.0	2.790	0.000	0.155
7.0	2.810	—0.020	0.135
7.5	2.830	—0.020	0.115
8.0	2.850	—0.020	0.095
9.0	2.890	—0.040	0.055
10.0	2.930	—0.040	0.015

Table III

KI soln.$=2.5M$. CdI$_2$ soln.$=0.25M$, taken$=40$ c.c. (Fig. 3).

KI added,	Temp.	Diff. in temp.	Total diff. (in temp.)
0 c.c.	2.080°	0.000°	0.000°
1	2.070	0.010	0.010
2	2.035	0.035	0.045
3	2.000	0.035	0.080
4	1.965	0.035	0.115
5	1.930	0.035	0.150
6	1.895	0.035	0.185
7	1.865	0.030	0.215
8	1.845	0.020	0.235
9	1.825	0.020	0.265
10	1.820	0.005	0.260
11	1.820	0.000	0.260
12	1.820	0.000	0.260
14	1.830	—0.010	0.250
16	1.840	—0.010	0.240
18	1.850	—0.010	0.230
20	1.860	—0.010	0.220

Table IV

KI soln.$=2.5M$. CdI$_2$ soln.$=M/6$, taken$=40$ c.c. (Fig. 4).

KI added.	Temp.	Diff. in temp.	Total diff. (in temp.)
0 c.c.	2.825°	0.000°	0.000°
1	2.795	0.030	0.030
2	2.750	0.045	0.075
3	2.705	0.045	0.120
4	2.665	0.040	0.160
5	2.630	0.035	0.195
5.5	2.615	0.015	0.210
6.0	2.600	0.015	0.225
6.5	2.585	0.015	0.240
7.0	2.570	0.015	0.255
7.5	2.560	0.010	0.265
8.0	2.550	0.010	0.275
10.0	2.540	0.010	0.285
12.0	2.530	0.010	0.295

TABLE V

CdI$_2$ soln.$=1.5M$. KI soln.$=0.3M$, taken$=40$ c.c. (Fig. 5).

CdI$_2$ added.	Temp.	Diff. in temp.	Total diff. (in temp.)
0.0 c.c.	2.930°	0.000°	0.000°
0.5	2.890	0.040	0.040
1.0	2.845	0.045	0.085
1.5	2.800	0.045	0.180
2.0	2.760	0.040	0.170
2.5	2.730	0.030	0.200
3.0	2.700	0.030	0.230
3.5	2.680	0.020	0.250
4.0	2.665	0.015	0.265
4.5	2.655	0.010	0.275
5.0	2.645	0.010	0.285
6.0	2.630	0.015	0.300
7.0	2.615	0.015	0.315
8.0	2.600	0.015	0.330
9.0	2.585	0.015	0.345
10.0	2.570	0.015	0.360

TABLE VI

KI soln.$=3.0303M$. CdSO$_4$ soln.$=M/3$, taken$=40$c.c. (Fig. 6).

KI added.	Temp.	Diff. in temp.	Total diff. (in temp.)
0 c.c.	4.510°	0.000°	0.000°
1	4.445	0.065	0.065
2	4.360	0.085	0.150
3	4.290	0.070	0.220
4	4.230	0.060	0.280
5	4.175	0.055	0.335
6	4.120	0.055	0.390
7	4.065	0.055	0.445
8	4.010	0.055	0.500
9	3.960	0.050	0.550
10	3.910	0.050	0.600
11	3.860	0.050	0.650
12	3.820	0.040	0.690
13	3.780	0.040	0.730
14	3.740	0.040	0.770
15	3.700	0.040	0.810
16	3.670	0.030	0.840
17	3.645	0.025	0.865
18	3.625	0.020	0.885
19	3.620	0.005	0.890
20	3.620	0.000	0.890
21	3.620	0.000	0.890
22	3.620	0.000	0.890
23	3.635	—0.015	0.875
24	3.645	—0.010	0.865
26	3.670	—0.025	0.840
28	3.700	—0.030	0.810
30	3.730	—0.030	0.780

Each titration has been repeated twice and the results agree with each other very closely.

DISCUSSION

Although the shape of the curves changes with concentration of cadmium iodide solution it is peculiarly interesting to note that the breaks in all the curves are at the points corresponding Cd-iodide : K-iodide$=1 : 2$ and Cd-iodide : K-iodide $1 : 3$. Thus the first breaks in the curves in Figs. 1 to 4 and second break in the curve in Fig. 5 indicate definitely the existence of the complex ion CdI$_4''$ in solution and the reaction at the break point is

$$Cd(CdI_4) + 4KI = 2K_2(CdI_4).$$
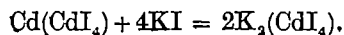
With further increase of KI_2 concentration, the complex ion CdI_4'' becomes CdI_5'' as follows

$$K_2(CdI_4) + KI = K_3(CdI_5)$$
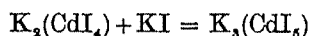
and so the second breaks in the curves in Figs. 1-4, and first break in Fig. 5 are observed.

FIG. 1.
KI soln. $= 5M$
CdI_2 soln. $= M/2$, 40 c.c.

FIG. 2
KI soln. $= 4.762M$
CdI_2 soln. $= M/4$, 40 c.c.
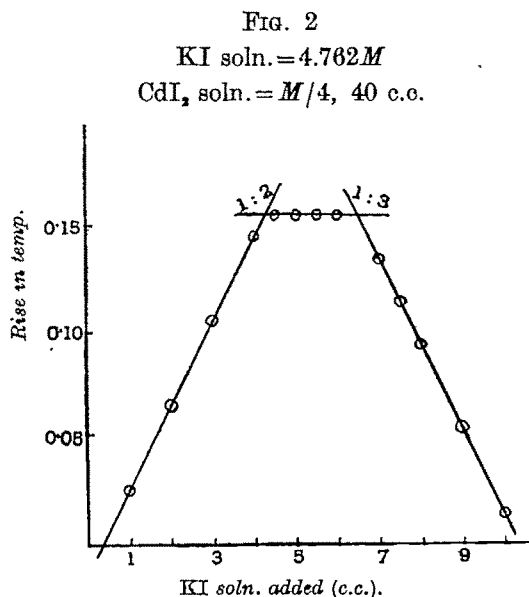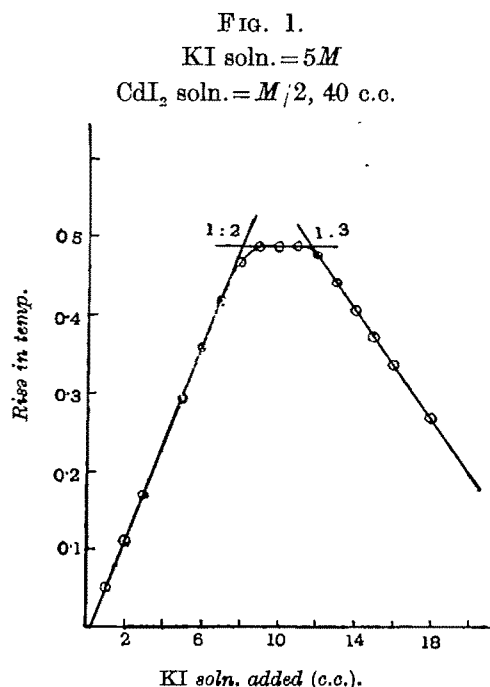
The absence of any break in the curves corresponding to $CdI_2 : KI = 1 : 1$ indicates that possibly the ion CdI_3' does not exist in solution and if it exists at all it is almost completely dissociated into Cd^{++} and I'. The results of the author are in agreement with those obtained from other physical methods, namely cryoscopy by Urbain and Cornec (*Bull. Soc. chim.*, 1919, 25, 137), absorption spectra by Job (*Compt. rend.*, 1925, 180, 1108), ebullioscopy by Burion and Mile O. Hun (*Compt. rend.*, 1930, 191, 97), phase rule by Herring (*Compt. rend.*, 1933, 197, 143) and Raman spectra by Dalwaulle, Francois and Wiemann (*Compt. rend.*, 1938, 206, 187; 1938, 208, 184). Cornec and Urbain have shown not only the existence of the complex ion CdI_4'' but also have
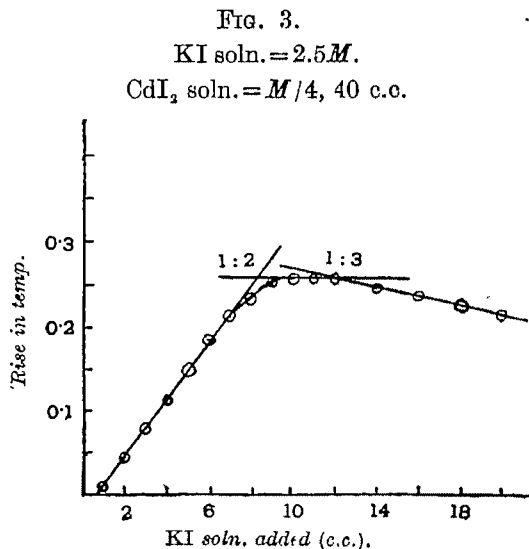
FIG. 3.
KI soln. $= 2.5M$.
CdI_2 soln. $= M/4$, 40 c.c.

observed with the system CdI_2—HI, that the ion CdI_3' is very unstable in moist air and so it is evident that the existence of the complex ion CdI_3' is not expected in solution as is indicated by the present experiment. Therefore the conclusion of McBain that Cd-miumiodide exists in concentrated solutions as Cd^{++} and CdJ_3' is not quite correct and is against the results obtained by different physical methods. It is further to be noted that no mention of the complex ion CdI_5''' in solution is found in the literature, although from phase rule study Herring has isolated the compound $CdI_2.3KI.4H_2O$ in the solid phase. In order to see whether any other Cd salt, when titrated with KI, gives indications about the existence of the complex ions

Fig. 4.

KI soln. $= 2.5M$. CdI_2 soln. $= M/6$, 40 c.c.

KI soln. added (c.c.).
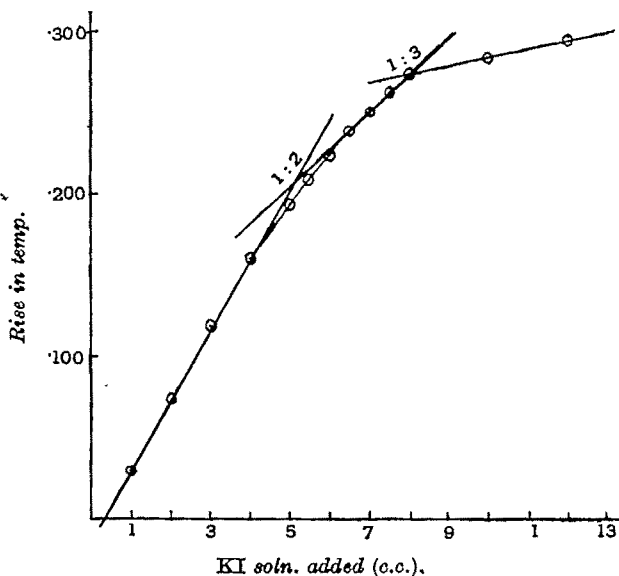
CdI_4'' and CdI_5''', Cd-sulphate solution has been titrated with KI solution. Fig. 6 (for $CdSO_4$—KI) shows four breaks corresponding to $CdSO_4 : KI = 1 : 1, 1 : 3, 1 : 4$ and $1 : 5$. The break corresponding to $1 : 1$ is due to the formation of the complex $K_2Cd(SO_4)_2$ in solution according to the equations given below :

$$2CdSO_4 + 4KI = Cd(CdI_4) + 2K_2SO_4$$
$$2CdSO_4 + 2K_2SO_4 = 2K_2 Cd(SO_4)_2$$

Adding

$$4CdSO_4 + 4KI = Cd(CdI_4) + 2K_2Cd(SO_4)_2$$
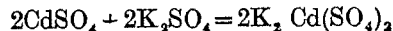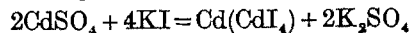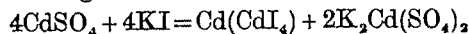
The third and fourth breaks corresponding to $1 : 4$ and $1 : 5$ are due to the ions CdI_4'' and CdI_5'''. But the second break corresponding to $1 : 3$ is not due to the ion $\sqcap$, as no break corresponding to this ion formation has been observed in CdI_2—KI-system. Further it is to be noted that the break corresponding to $CdSO_4 : KI = 1 : 2$ has not been observed in the curve, although it is expected to be present if the complex ion CdI_4'' is formed in solution according to the equation,

Fig. 5.

KI soln. $= 0.3M$. CdI_2 soln. $= 1.5M$, 40 c.c.

CdI_2 soln. added (c.c.).

$$2CdSO_4 + 4KI = Cd(CdI_4) + 2K_2SO_4.$$
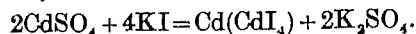
Fig. 6.

KI soln. $= 3.0303M$. CdSO$_4$ soln. $= M/3$, 40 c.c.

KI *soln. added* (c.c.).
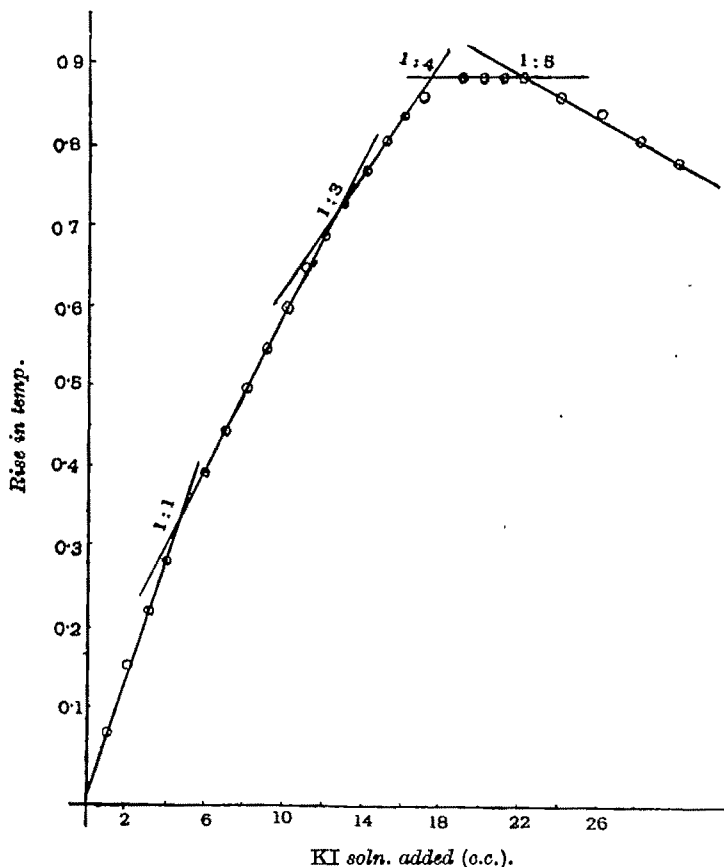
This is explained by the fact that a certain amount of the complex ion CdI$_4$″ has been formed at the point CdSO$_4$: KI $= 1 : 1$, and so when further KI solution is added, a portion of it reacts with Cd(CdI$_4$) and converts it into K$_2$(CdI$_4$) and the remaining portion reacts with K$_2$Cd(SO$_4$)$_2$ converting it to Cd(CdI$_4$). Thus if only K$_2$(CdI$_4$) would have been formed, the break would have appeared at the point corresponding to CdSO$_4$: KI $= 1 : 4$ and again if only Cd(CdI$_4$) would have been formed, the break at the point corresponding to CdSO$_4$: KI $= 1 : 2$ would have been noted. Since both the processes are taking place simultaneously *i.e.*, breaks corresponding to $1 : 4$ and $1 : 2$, the break near about $2 : 6$ or $1 : 3$ appears. The definite indication of the existence of the complex ion CdI′$_6$″ in solution by the thermometric method shows that by this method not only the complex ion predicted by other methods are noted but in addition where other physical methods fail, it can be used with great success provided the heat change is sufficient.

My best thanks are due to Dr. P. B. Sarkar for taking keen interest in the subject and helpful suggestions and for all laboratory facilities.

SCHIFF'S BASES FROM SODIUM ARSANILATE

By S. C. Chaudhury, T. N. Ghosh and U. P. Basu

Various aldehydes have been condensed with sodium arsanilate to furnish *Schiff's* bases, which react with sodium bisulphite to yield soluble compounds. These might prove useful in arsenic therapy.

Sodium arsanilate (Atoxyl, Soamin) is used in cases of anaemia, syphilis, elephantiasis, malaria and other protozoal diseases. It is, however, found to be somewhat toxic and its toxic effect is cumulative, often leading to complete blindness. Moreover, solution of sodium arsanilate cannot be sterilised, as it suffers decomposition.

Other isomers of atoxyl (*ortho*- and *meta*-) are inferior to atoxyl in trypanocidal acitivity, while the former is more toxic. The presence of a second amino group in atoxyl decreases still further the toxicity but unfortunately the activity towards parasites is also decreased, while it disappears altogether on the introduction of a third amino group. This decreasing activity is partially connected with the increasing ease with which the substances are eliminated from the body. It is therefore evident that the activity of atoxyl is associated with the presence of *para*-amino group and its toxicity has been decreased by acylation of this *para*-amino group and/or by the introduction of a hydroxyl group in the benzene nucleus. *p*-Acetylaminophenylarsonic acid is only one-third as toxic as atoxyl, but is three times therapeutically active. Aminohydroxyphenylarsonic acids are much less toxic than atoxyl and are found to manifest both trypanocidal and spirillocidal properties. The toxicity of atoxyl has also been decreased by preparing the corresponding carbamido and phenylglycine derivatives of *para*-arsanilic acid. The former is less than half as toxic as atoxyl and equally effective therapeutically, and is particularly useful in amoebic dysentery. The latter in the form of sodium salt is known as Tryparsamide which is readily soluble in water, can be sterilised and has considerable use in the treatment of sleeping sickness.

Inspite of the intensive research in arsenical derivatives, it is doubtful if any compound has been discovered which is quite without effect on the nervous system of the host, when administered over a long period. With atoxyl and its analogues, so far prepared, this action on nervous system is particularly noticeable, specially over the optic nerve.

The amino group of *para*-arsanilic acid has been condensed with various aldehydes to form the *Schiff's* bases of the type (I), with a view to reducing toxicity to the nervous system. The latter compounds readily react with sodium bisulphite to form products of the structure (II), which are readily soluble in water and are sufficiently stable to withstand sterilisation by heat or even by autoclaving.

$$\text{R.CH}=\text{N}\!-\!\!\left<\!\!=\!\!\right>\!-\!\text{As}\!\!\begin{array}{c}\nearrow\text{OH}\\=\text{O}\\\searrow\text{ONa}\end{array}\qquad\text{R}\!-\!\underset{\underset{\text{SO}_3\text{Na}}{|}}{\text{CH}}\!-\!\text{NH}\!-\!\!\left<\!\!=\!\!\right>\!-\!\text{As}\!\!\begin{array}{c}\nearrow\text{OH}\\=\text{O}\\\searrow\text{ONa}\end{array}$$

(I)   (II)
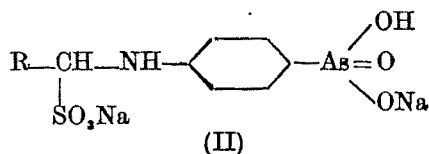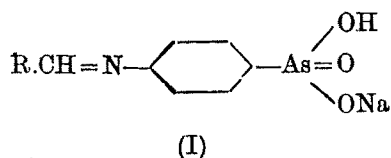
EXPERIMENTAL

Condensation of Sodium Arsanilate with Aldehydes.—Sodium arsanilate containing about 2.5 molecules of water of crystallisation (1 part) was mixed with the aldehyde (1.25 parts) in dilute (3 : 1) alcoholic solution, so that the whole remained as a clear solution. It was then refluxed for about 2 hours on the water-bath and left overnight, when a crystalline solid separated out. The vessel was cooled in ice and the solid was filtered, washed with dilute alcohol and dried. The yield in most cases was found to be equal to the amount of sodium arsanilate taken. The products were crystallised from dilute alcohol and found to decompose without melting.

The general characteristics of the various *Schiff's* bases are recorded in Table I. Arsenic was determined by oxidation with acid permangante according to the method of Rupp and Lehmann (*Apoth. Z.*, 1911, 26, 200), slightly modified, and nitrogen by the Dumas method.

TABLE I

Schiff's bases

Base from	Nature.	Formula.	M.W.	Arsenic		Nitrogen	
				Calc.	Found.	Calc.	Found.
Formaldehyde	Colourless, hygroscopic solid	$C_8H_{11}O_5N$ NaAs	298.9	25.06%	24.0%	4.7%	4.05%
Benzaldehyde	Colourless crystals	$C_{13}H_{11}O_3N$ NaAs	326.9	22 9	23.8	4.28	4.40
Anisaldehyde	Colourless needles	$C_{14}H_{13}O_4N$ NaAs	356.9	21.0	22.1	3.92	4.2
Salicylaldehyde	Yellow shining needles	$C_{13}H_{11}O_4N$ NaAs	342.9	21.84	22.7	4.08	4.4
Cinnamic aldehyde	Yellow flakes	$C_{15}H_{13}O_3N$ NaAs	352.9	21.2	22.0	3.96	4.5
Dimethyl aminobenzaldehyde	Colourless needles	$C_{15}H_{16}O_3N_2$ NaAs	369.9	20.25	21.6	7.56	7.65

Reaction with Sodium Bisulphite.—The Schiff's base, obtained above, was treated with a freshly prepared solution of a molecular quantity of sodium bisulphite, made by passing sulphur dioxide gas into an aqueous solution of a molar amount of sodium carbonate required. The mixture was gently warmed on a water-bath for a few minutes, when an almost clear solution was obtained which was allowed to stand overnight. Next day the solution was filtered, concentrated on a water-bath and then diluted with excess of alcohol, when a colourless solid separated out, which was filtered, purified by solution in water and reprecipitation with alcohol and was finally dried *in vacuo*.

The various bisulphite derivatives isolated were found to be somewhat contaminated with sodium bisulphite and/or sodium sulphite (*cf.* Ghosh and Mitra, *Science & Culture*, 1945, 10, 452). It was found difficult to remove the inorganic impurities from most of the compounds and hence the analysis of arsenic in the product indicated a lower percentage of the metal. The products in case of Schiff's bases isolated from benzal-

dehyde and anisaldehyde were, however, found pure. The former, [PhCH(SO$_3$Na)-NH.C$_6$H$_4$-As(OH)(ONa) : O], gave N, 3.20 and As, 17.0% ; C$_{13}$H$_{12}$O$_6$NSNa$_2$As requires N, 3.24 and As, 17.38%. The corresponding product from anisaldehyde *viz.*, CH$_3$O.C$_6$H$_4$.CH(SO$_3$Na).NH.C$_6$H$_4$.As(OH)(ONa) : O, gave N, 3.2 and As, 15.5% ; C$_{14}$H$_{14}$O$_7$NSNa$_2$As requires N, 3.04 and As, 16.2 per cent.

The Schiff's base from cinnamic aldehyde and sodium arsanilate also furnished a bisulphite compound, which on analysis was found to contain 10% arsenic, whereas theory demands 13.3%. This product was dissolved in minimum quantity of water and precipitated by addition of alcohol free from aldehyde. The sulphated ash from it was found to be 43.6%, whereas C$_{15}$H$_{15}$O$_9$NS$_2$Na$_4$ As would have afforded 37.9% solid as Na$_2$SO$_4$ by theory. Purification by reprecipitation was not effective.

This bisulphite compound was dissolved in *aqua-sterilisuta* to afford 6.5% solution (p_H 8.6), filled into resistant ampoules and sterilised by heating at 10 lbs. pressure for 30 minutes. The p_H was not altered by this sterilisation. The toxicity of this sterile solution had been studied by Dr. A. N. Bose of this laboratory, by injecting it subcutaneously into mice and by comparing to that of a solution containing the same amount of arsenic as present in sodium arsanilate. It has been observed that by this substitution in the *p*-amino group of sodium arsanilate the resultant compound has been found definitely to be of lower toxicity than atoxyl. It has also been observed that the bisulphite derivative in solution does not alter in stability nor shows any increase in toxicity when stored at room temperature even for about a year. These observations indicate that the sodium bisulphite derivatives of the *Schiff's* bases obtained from sodium arsanilate may offer some tharapeutic advantage.

INDIGOID VAT DYES OF THE ISATIN SERIES. PART V. 3-INDOLE-2'-(5'-CHLORO) THIONAPHTHENE-INDIGOS

By Sisir Kumar Guha and H. P. Basu-Mallick

A few 3-indole-2'-(5'-chloro)thionaphthene-indigos have been prepared by condensing 5-chloro-3-hydroxythionaphthene with isatin and some of its substituted products respectively. Their colour and the dyeing shades on wool and on cloth have been compared with those obtained from the mother compounds as well as from the corresponding 5'-methyl compounds.

5 : 5'-Dichlorothioindigo has been obtained in violet-red needle-shaped crystals.

The studies on the influence of a methyl radical, when present in every theoretically possible different position of the thionaphthene nucleus of 3-indole-2'-thionaphthene-indigos, were made complete in previous parts of this series of papers as the result of which a relation between the change in colour and constitution of a good number of isomeric 3-indole-2'-(methyl)thionaphthene-indigos was deduced (Guha and Basu-Mallick, *J. Indian Chem. Soc.*, 1934, **11**, 395 ; Guha, *ibid.*, 1937, **14**, 240 ; 1938, **15**, 501 ; 1944, **21**, 87).

With a view to testing how far this holds good in the case of 3-indole-2'-thionaphthene-indigos having a different type of substituent present in the thionaphthene ring of the molecule of the dyes, the present investigation was undertaken. Here the substituent chosen is Cl atom which is not the same in character as the methyl radical.

5-Chloro-3-hydroxythionaphthene (D.R.P. 224567 ; Friedlander, *Ber.*, 1877, **10**, 474 ; Auwers and Thies, *Ber.*, 1920, **53**, 2285) has been condensed with isatin and its 5-bromo-5 : 7-dibromo, and 5 : 7-dinitro derivatives respectively and another series of thioindigoid dyes prepared which may be represented by the general formula (I).

(I)
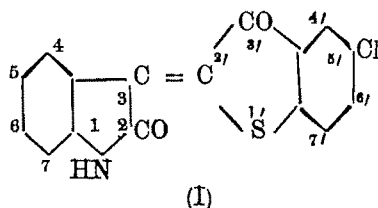
These 5'-chloro compounds are violet-red crystalline substances ; all are soluble in pyridine and nitrobenzene, sparingly soluble in alcohol. Cold concentrated sulphuric acid dissolves them producing either faint or deep blue solution from which the original dyes are re-precipitated unchanged in a flocculent state on the addition of water. They melt when heated above 290°. They easily impart deep shades to cloth from alkaline hydrosulphite vat and the dyeing shades on wool have been also uniformly developed from an acid bath.

The various isomeric indole-(methyl)thionaphthene-indigos (*loc. cit.*) were found easier to work with in the vat than those of the isomeric (methyl)thionphthene-acenaphthylene-indigos (Guha, *J. Indian Chem. Soc.*, 1933, **10**, 682 ; 1936, **13**, 94 ; 1938, **15**, 20 ; 1943, **20**, 37). Now it has been found that 3-indole-2'(5'-chloro)thionaphthene indigos can be worked with in the vat more conveniently than those of the corresponding

isomeric indole(methyl)thionaphthene-indigos. Consequently the shades of these chloro compounds have been quickly and uniformly developed on cotton from alkaline hydrosulphite vat.

A comparison of colour of these 5′-chloro compounds and their dyeing shades on wool and on cotton with those obtained from their parent compounds, namely, Thioindigo Scarlet R, Ciba Red G and 3(5 : 7-dinitro)indole-2′-thionaphthene-indigo (Guha, *J. Indian Chem. Soc.*, 1938, **15**, 508) and also their 5′-methyl derivatives (Guha and Basu-Mallick, *loc. cit.*) indicated clearly that the effect of a Cl atom in 5′-position of the thionaphthene ring of 3-indole-2′-thionaphthene-indigos is to alter the colour of the parent compounds so that "bathochromic" effect is produced. Secondly, the influence of a Cl atom in 5′-position is more powerful than a methyl radical in the same position in changing the colour of the parent compounds. All these relations will be clearly understood from a comparative study of the dyeing shades obtained from some of the compounds belonging to the three series, described in Table I. The quantitative measurement of the absorption maxima of the 5′-chloro compounds will be communicated later.

<center>TABLE I</center>

<center>Me=Methyl.   T=Thionaphthene-indigo</center>

Compounds.	Dyeing shade	
	on wool.	on cotton.
3-Indole-2′-T (Thioindigo Scarlet R)	Scarlet-red	Scarlet-red
3-Indole-2′(5′-Me)T	Brilliant scarlet red	Red (full shade not developed)
3-Indole-2′-(5′-chloro)T	Deep red	Deep red
3-(5 : 7-Dibromo)indole-2′-T (Ciba red G)	Yellowish -red	Yellowish red
3(5 : 7-Dibromo)indole-2′-(5′-Me)T	Deep red	Deep red
3-(5 : 7-Dibromo)indole-2′-(5′-chloro)T	Violet-red	Violet red
3-(5 : 7-Dinitro)indole-2′-T	Dark red	Dark red
3-(5 : 7-Dinitro)indole-2′-(5′-Me)T	Dark red	Dark red
3-(5 : 7-Dinitro)indole-2′(5 -chloro)T	Violet-red	Deep violet-red

5 : 5′-Dichlorothioindigo(Thioindigo Red BG) was required for another piece of work. It has been described to be a bluish red powder (Rowe, Colour Index, No. 1209, 1924 edition). It has been now obtained in violet-red, well defined crystals from a pure specimen of 5-chloro-3-hydroxythionaphthene.

<center>EXPERIMENTAL</center>

3-Indole-2′-(5′-chloro)-thionaphthene-indigo.—A solution of isatin (0.155 g.) and 5-chloro-3-hydroxythionaphthene (0.197 g.) in hot glacial acetic acid (43 c.c.) on treatment with concentrated hydrochloric acid (3.5 c.c., *d* 1.12) turned quickly dark red. The whole of the mixture was boiled for 20 minutes during which silky violet-red crystalline dye separated (0.205 g.). It was crystallised from xylene in clusters of star-shaped crystals. It is moderately soluble in xylene and acetic acid ; sparingly soluble in benzene and chloroform. Concentrated sulphuric acid dissolves it producing a faint blue colour. It imparts a deep red shade to wool from an acid bath and cotton in the same shade from light greenish yellow hydrosulphite vat. (Found : Cl, 11.44. $C_{16}H_8O_2N$ SCl requires Cl, 11.32 per cent).

3-(5-Bromo)indole-2'-(5'-chloro)thionaphthene-indigo was similarly obtained as violet-red needles from 5-bromoisatin (0.678 g.) and 5-chloro-3-hydroxythionaphthene (0.553 g.) in glacial acetic acid (50 c.c.) and concentrated hydrochloric acid (4 c.c.).   The dye (0.337 g.) was crystallised from a mixture of pyridine and nitrobenzene (3 : 1) in deep violet-red small needles. It is slightly soluble in chloroform and benzene ; insoluble in xylene. The solution in concentrated sulphuric acid is of the same colour as that of the preceding compound. The dyeing shades on wool from an acid bath and on cotton from light greenish yellow hydrosulphite vat are violet-red. (Found : N, 3.73. $C_{16}H_7O_2NClBrS$ requires N, 3.56 per cent).

3-(5 : 7-Dibromo)indole-2'(5'-chloro)thionaphthene-indigo separated in small thread-like violet-red needles from 5 : 7-dibromoisatin (0.634 g.) and 5-chloro-3-hydroxythionaphthene (0.384 g.) in 55 c.c. of glacial acetic acid and concentrated hydrochloric acid (5 c.c.) by heating for 20 to 25 minutes. The product (0.332 g.) was crystallised from pyridine in wooly needle-shaped crystals. It is sparingly soluble in acetic acid and chloroform. Concentrated sulphuric acid dissolves it producing a blue solution. It dyes wool from an acid bath and cotton from light greenish yellow hydrosulphite vat in slightly deeper violet-red shade than that obtained from the 5-bromo dye. (Found : N, 3.35. $C_{16}H_6O_2NClBr_2S$ requires N, 2.96 per cent).

3-(5 : 7-Dinitro)indole-2'-chloro(5'-thionaphthene-indigo was obtained as deep violet-red needles from 5 : 7-dinitro-isatin (0.711 g.) and 5-chloro-3-hydroxythionaphthene (0.553 g.) in 30 c.c. of glacial acetic acid and concentrated hydrochloric acid (3.5 c.c.) by heating for 20 to 25 minutes. The substance (0.205 g.) was crystallised from benzene in fine, long, pointed needles. It is soluble in acetic acid ; moderately soluble in chloroform and benzene. It dissolves in concentrat sulphuric aciedd producing the same. colour as the dibromo dye. It dyes wool in violet-red shade from an acid bath and cotton in deep violet-red shade from yellow hydrosulphite vat. (Found : Cl, 8.3. $C_{16}H_6O_6N_3ClS$ requires Cl, 8.77 per cent). .

5 : 5'-Dichlorothioindigo.—5-Chloro-3-hydroxythionaphthene, dissolved in hot sodium hydroxide solution (2N approx.) was treated with potassium ferrocyanide solution (5%) gradually and shaken. The mixture was heated on the water-bath for 1 hour for the complete precipitation of the dye. The compound separated from nitrobenzene in clusters of needle-shaped violet-red crystals not melting below 305°. (Found : Cl, 19.26. $C_{16}H_6O_2Cl_2S_2$ requires Cl, 19.45 per cent).

SYNTHESIS OF CYANINE DYES BY THE CONDENSATION OF p-DIETHYLAMINO-BENZALDEHYDE WITH APPROPRIATE HETEROCYCLIC COMPOUNDS. PART II.

By M. Q. Doja and Jogesh Chandra Banerjee

In view of the fact that the cyanine dyes of the thiazole series are commercially valuable sensitisers, five new dyestuffs of this group have been synthesised by the condensation of p-diethylaminobenzaldehyde with the methiodides of 2 : 4-dimethylthiazole, 2-methyl-4-phenylthiazole, 2-methylbenzothiazole, 2-methyl-α-naphthathiazole and 2-methyl-β-naphthathiazole. The chemical, dyeing, optical and photographic properties of these compounds have been examined. A comparison has also been made with the corresponding dimethylamino derivatives prepared by the condensation of p-dimethylaminobenzaldehyde with these heterocyclic ammonium compounds. The preparation of some of the "intermediates" has also been described.

In view of the fact that in modern photographic plate manufacture cyanine dyes of the thiazole series (Hofmann, *Ber.*, 1887, **20**, 2262 ; König and Treichel, *J. prakt. Chem.*, 1921, **102**, 63 ; Mills and Smith, *J. Chem. Soc.*, 1922, **121**, 2724 ; Smith, *ibid.*, 1923, **123**, 2288 ; Konig, *Ber.*, 1928, **61**, 2065 ; Hamer, *J. Chem. Soc.*, 1929, 2598 ; Fisher and Hamer, *ibid.*, 1930, 2502 ; Ogata, *Proc. Imp. Acad. Tokyo*, 1933, **9**, 602 ; Brooker and White, *J. Amer. Chem. Soc.*, 1935, **57**, 2480 ; Kiprianov, Sitnik and Sitsch, *J. Gen. Chem. Russia*, 1936, **6**, 42, 576 ; Beilenson and Hamer, *J. Chem. Soc.*, 1936, 1225 ; Kiprianov and Sitsch, *Trans. Inst. Chim. Charkov*, 1936, **2**, 15) are being increasingly used, it was of interest to synthesise and examine the properties of a new class of sensitising dyes, prepared by the condensation of p-diethylaminobenzaldehyde (*cf.* B.P. 449527) with quaternised thiazole bases containing a reactive methyl group, represented by the general formula (D). It was also intended to study the change in photographic properties of these dyes with increase in the size of the thiazole nucleus, and for this reason, two simple thiazoles, one benzothiazole, and two naphthathiazole derivatives have been chosen for these condensations ; the quaternary compound being prepared in each case by the addition of methyl iodide. Thus structurally the dyes differed from one another only in the nature of their thiazole nuclei.

(D)
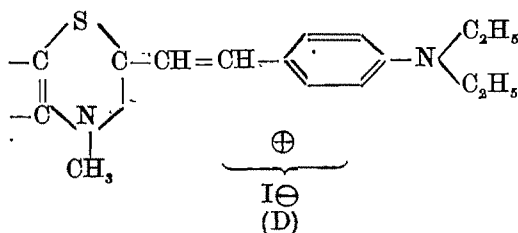
The dyestuffs have been prepared by the interaction of the methiodides of 2-methyl-4-phenylthiazole, 2-methylbenzothiazole, 2-methyl-α-naphthathiazole and 2-methyl-β-naphthathiazole with p-diethylaminobenzaldehyde in absolute alcoholic solution, catalysed by small quantities of piperidine. In the case of 2 : 4-dimethylthiazole-methiodide, the condensation is effected in acetic anhydride solution, and no catalyst is used. It has been noticed that the methiodides of simple thiazoles undergo dye-condensation of this kind less readily than the methiodides of condensed thiazole systems.

Some of the properties of these dyestuffs are summarised in Table I.

TABLE I

Compound	Colour, shape and "Form"	M.p.	Colour in cold conc. H_2SO_4.	Reflex.	PLEOCHROISM Colour of light in one position of Polariser	Colour after rotation through 90°	Remarks	Relative intensity of colour in solution		Relative resistance to decolourisation	Extra Sensitization Range.	Maximum.
V	Dull steel blue, thin elongated needle clusters, (Hypidiomorphic)	157-158°	Pink	Weak, Bluish green	Brownish red	Pink	Some of the crystals shine like mica	1	Simple thiazole derivatives	1	5200-6000 Å	5450 Å
W	Beautiful shining, greenish blue, stout needles (Idiomorphic)	211-212°	Pinkish brown	Strong, Greenish blue	Amethyst	Deep reddish violet	Some surfaces look like plate glass	1·53		1·4	5150-6250 Å	5600 Å
X	Bronze, felted needles (Allotriomorphic)	224° (begins to shrink in volume from 140°)	Brownish-pink	Strong, Old Gold	Nil	Nil	Looks like glass thread	1	Condensed thiazole derivatives	8·5	5200-6350 Å	5700 Å
Y	Dirty green, spheroidal granules	243-244°	Flourescent, dirty green	Very weak, Grass green	Yellowish grey	Brassy yellow	Bigger particles exhibit beautiful greenish flourescence	1·15		2·7	5400-5950 Å	Not definite
Z	Sage green granular crystals	173-174°	Flourescent, yellowish green	Strong, Bottle green	Light yellow	Opaque	Some of the crystals shine like yellow diamond	1·07		2·2	5250-6500 Å	5750 Å

Note :—(V), (W), (X), (Y) and (Z), represent respectively the methiodides of 2-*p*-diethylaminostyryl—,

—4-methyl-thiazole ;
—4-phenyl-thiazole ;
—Benzo-thiazole ;
—α-Napthathiazole and
—β-Naphthathiazole.

All the five compounds are insoluble in cold but very slightly soluble in boiling water. They are freely soluble in methyl alcohol, ethyl alcohol, *n*-propyl alcohol, *iso*amyl alcohol, chloroform and acetic acid, and insoluble in ether and benzene, except (V) which is moderately soluble in the latter solvent.

Dilute solutions are all coloured, the two substituted simple thiazole derivatives (V) and (W) being reddish yellow, the reddish tinge increasing with increase in molecular weight; and the three condensed thiazole- derivatives (X), (Y) and (Z), are magneta coloured, the colour deepening with increasing molecular weight. The relative intensities of dilute solutions (1 : 100000) of these two sets of compounds in rectified spirit as determined by means of a Duboscq Colorimeter (Snell, " Colorimetric Methods of Analysis," 1936, p. 43, Chapman and Hall Ltd.) are given in Table I.

It will be noticed that the introduction of a phenyl group in 4-position in the simple thiazole derivative in place of methyl increases the intensity of colour by about 50%. Among the condensed thiazole derivatives, the α-naphthathiazole compound forms relatively the most intensely coloured solution.

As compared with the corresponding symmetrical carbocyanines (Mills, *J. Chem. Soc.*, 1922, **121**, 455; Hamer, *ibid.*, 1929, 2598; Fisher and Hamer, *ibid.*, 1930, 2502) these unsymmetrical cyanines are less deeply coloured. This is due to the lower degeneracy of these unsymmetrical cyanines, brought about by the presence of the single benzene ring in the chromophoric chain which is known to inhibit resonance along that chain.

TABLE II

Methiodide of	Corresponding *p*-di-ethylamino compound	Appearance of solid	M.p.	Colour in dilute solution.	Reflex.	Sensitisation Extends to	Maximum	Reference
2-*p*-Dimethyl-aminostyryl-4-methylthiazole-	(V)	Red needles	269°	Deep orange	Blue	5950° Å	5500° Å	Smith, *J. Chem. Soc.*, 1923, **123**, 2291
2-*p*-Dimethyl-aminostyryl-4-phenylthiazole-	(W)	Ruby red crystals	243°	Deep orange	Bluish green	6200	5500	Mills and Smith, *J. Chem. Soc.*, 1922, **121**, 2735
2-*p*-Dimethyl-aminostyryl-benzothiazole-	(X)	Steel blue needles	250°	Purple	*nil*	6700	5700	Smith, *J. Chem. Soc.*, 1923, **123**, 2292
2-*p*-Dimethyl-aminostyryl-*a*-naphthathiazole-	(Y)	Prismatic crystals	232°	Magenta	Green	6800	5900	*idem.*, page 2294
2-*p*-Dimethyl-aminostyryl-*β*-naphthathiazole-	(Z)	Lustrous blue needles	256°	Purple	*nil*	6700	6100	Do.

The symmetrical dyes, on the other hand, on account of the identity of the two hetero-cyclic nuclei, possess completely degenerate resonance structures, and are therefore more deeply coloured (Brooker and Sprague, *J. Amer. Chem. Soc.*, 1941, **63**, 3203; also see Brooker *et al, ibid.*, p. 3192; Brooker and Sprague, *ibid.*, p. 3214; Brooker, Keyes and Williams, *ibid.*, 1942, **64**, 199; Brooker, *Rev. Modern Physics*, 1942, **14**, 275).

The unsymmetrical and symmetrical cyanines resonate according to the schemes I(a) $\longleftrightarrow$ I(b) and II(c) $\longleftrightarrow$ II(d) respectively.

I(a)   I(b)

II(c)   II(d)
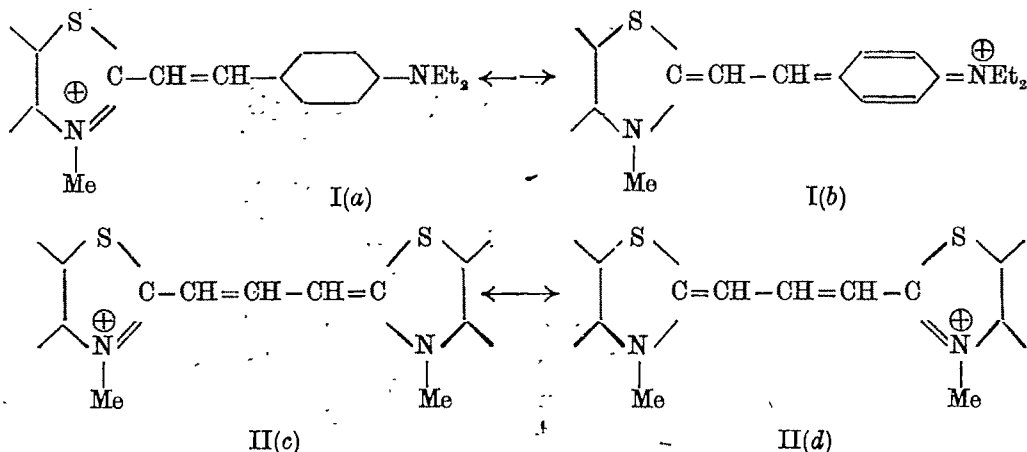
·In a resonating system, the benzenoid configuration is known to be more stable than the quinonoid, and hence the actual state of the compound (I) will tend towards I(a). The compound will therefore lose, in corresponding measure, its nature as a resonance hybrid, and its colour will be lighter in consequence. There is no such degeneracy-inhibiting factor in (II), the two states have nearly the same energy and therefore nearly the same stability, which means higher resonance, higher degeneracy, and deeper colour.

A noteworthy observation, the explanation of which is obscure at present, is that the acetic acid solutions of these dyestuffs deepen in colour on warming. When the solutions are cooled the intensity diminishes and the original colour is slowly regained. The effect is more pronounced in aqueous-acetic acid solutions.

Like other cyanine dyes the colour of the solutions of these compounds is reversibly discharged by the addition of mineral acids. In Table I is given the " relative resistance " of these newly synthesised dyestuffs to.decolorisation by $N/100$ hydrochloric acid. The exceptional resistance of the benzothiazole derivative (X) is particularly noticeable. The difference between the α- and β-naphthathiazole compounds having the same molecular weight, is remarkable.

The discharge of colour by the addition of mineral acids (cf. Brooker, Sprague, Smyth and Lewis, J. Amer. Chem. Soc., 1940, 62, 1116) is probably due to the destruction of the conjugated system, responsible for the colour of the dyestuff, as suggested in (E)

(E)
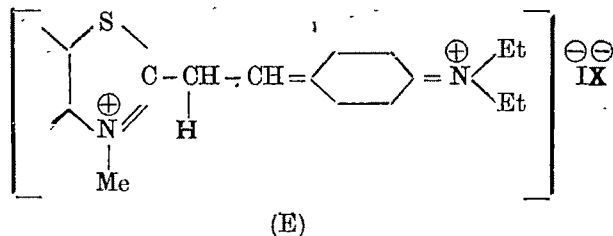
Silk, wool and cotton have been dyed with these compounds in the usual way (Whittaker and Wilcock, "Dyeing with Coal-tar Dyestuffs", 1939, Bailliere Tindall & Cox, London)

Fig 1(a)

Sensi-
tisation.

Absorp-
tion.

V {

W {

X {
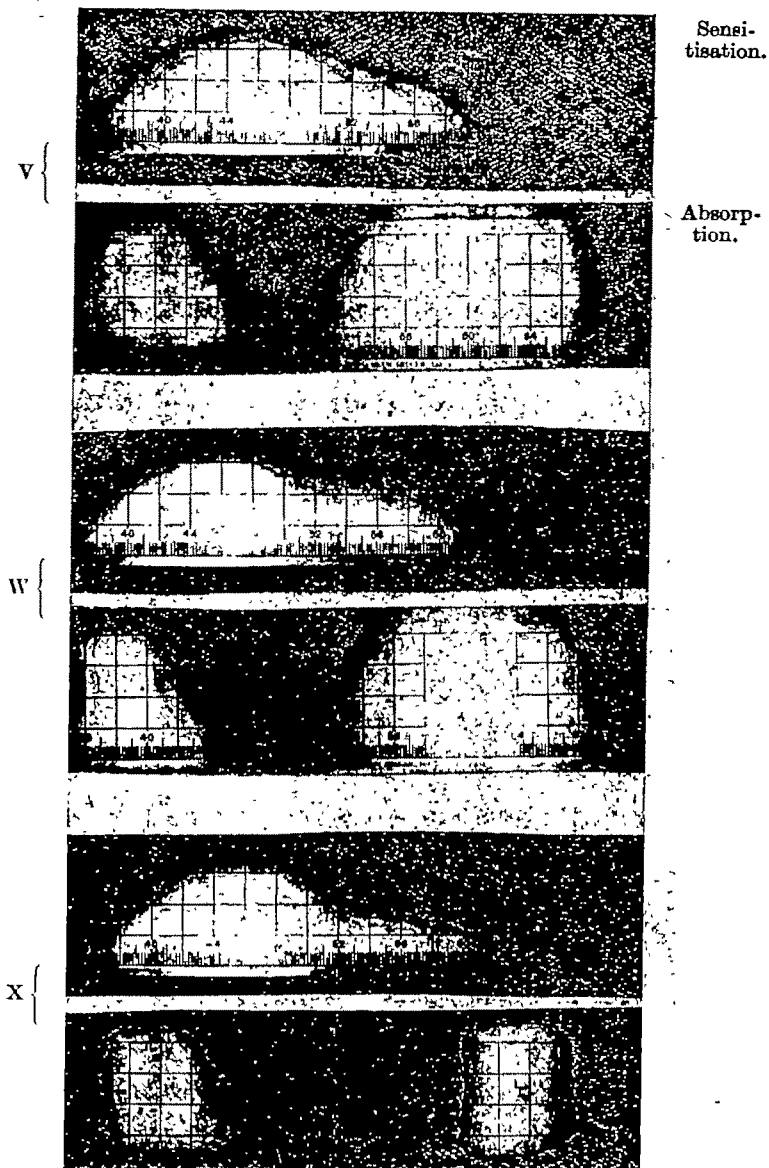
Fig. 1(b).
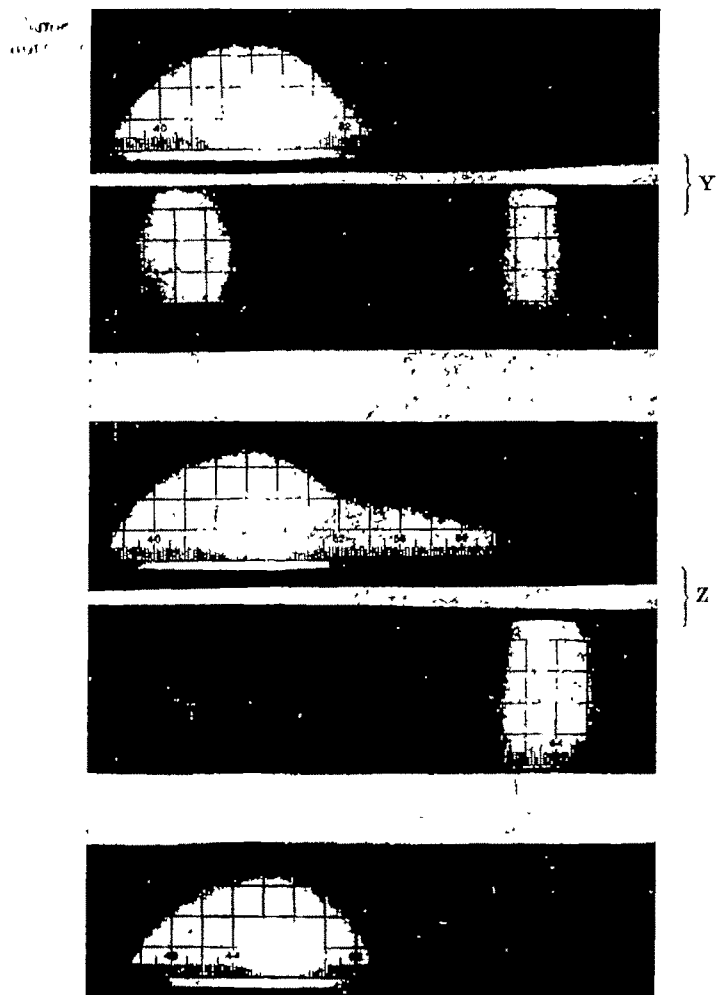
and the shades obtained are recorded in Table III. None of the shades is fast either to sunlight or to soaping. When exposed to sunlight, the colour of (Y) is discharged most rapidly and that of (V) most slowly.

TABLE III

Compound	Silk	Colour produced on Wool	Cotton
(V)	Pinkish orange	Pinkish orange	Pink
(W)	Crimson	Light blood red	Bluish crimson
(X)	Violet red	Reddish violet	Purple
(Y)	Mauve	Violet	Mauve
(Z)	Mauve	Violet	Mauve

The flourescence of weak alcoholic solutions (1 : 100000) of these compounds (cf. Doja, *J. Indian Chem. Soc.*, 1940, **17,** 348) is given in Table IV.

TABLE IV

Wallace Colour Filter No.	Colour of the fluorescent beam seen at right angles to the incident beam				
	(V)	(W)	(X)	(Y)	(Z)
1	Light absorbed	Light absorbed	Light absorbed	Light absorbed	Light absorbed
2	Light absorbed	Light absorbed	Light absorbed	Weak brownish red	Very weak red
3	Sulphur yellow	Weak yellow	Brownish yellow	Pinkish red	Reddish yellow
4	Light absorbed	Light absorbed	Weak brown	Flaming red	Orange red
5	Lemon yellow	Lemon yellow	Yellowish brown	Yellowish red	Yellowish red
6	Deep lemon yellow	Brownish yellow	Dirty yellow	Yellowish red	Brownish red
7	Greenish brown	Greenish yellow	Greenish yellow	Orange red	Brownish red
8	Brownish yellow	Brownish yellow	Brownish orange	Orange red	Flaming red
9	Bluish white	Orange yellow	Carrot yellow	Dull bluish red	Bluish red
10	Brownish yellow	Bright yellow	Brownish yellow	Orange red	Dirty yellow

Photographs of absorption and sensitisation spectra of all the five compounds, determined by means of a Wedge spectrograph, are shown in Fig. 1. For the sake of comparison, in each case, the absorption spectrum is given below the sensitisation spectrum. Among the compounds examined, the β-naphthathiazole derivative (Z) is the most powerful sensitiser, extending the sensitisation up to λ 6500. The extra-sensitisation, however, although extensive, is not very intense. The α-naphthathiazole compound (Y), on the other hand, is the poorest sensitiser of the whole lot. (W), the 4-phenylthiazole compound is a valuable " green " sensitiser, suitable for the manufacture of orthochromatic plates. Its extra-sensitisation is not only intense, but is also free from the common defect of a " gap " in the blue green region of the spectrum. Except in the case of the α-naphthathiazole compound (Y), increase in molecular weight of the dyestuff, extends the band of extra-sensitisation farther towards the red end of the spectrum. The salient features of the sensitisation spectra of these compounds are summarised in Table I.

Like other styryl compounds (Bloch and Hamer, *Phot. J.*, 1930, **54**, 374) the absorption spectra are all single banded, reflecting the essential similarity in the structure of these compounds.

From the point of view of similarity in properties, the five compounds investigated fall into two groups. The first comprises the two simple thiazole derivatives (V) and (W), which have nearly the same colour, similar absorption and similar sensitisation. The second group consists of the three condensed thiazole derivatives (X), (Y) and (Z). Notwithstanding their identical molecular weights and very similar structure, the great difference in the sensitising powers of α- and β-naphthathiazole compounds (Y) and

(Z) are noteworthy. In their yields and solubility in methyl alcohol too, they markedly differ. The β-compound (Z) is more freely soluble and also gives a higher yield than the α-compound. It is interesting to compare these results with the observations of Hamer (*J. Chem. Soc.*, 1929, 2601, 2606) in regard to the corresponding 2-*p*-dimethyl-aminostyryl-α- and -β-naphthathiazole ethiodides. She has also found the β-compound to be more soluble in methyl alcohol than the α-compound. In the matter of yields, however, reverse is the case, it is the α-compound which gives the higher yield.

In order to compare the properties of these new dyestuffs with the corresponding dimethylamino compounds (prepared by the condensation of *p*-dimethylaminobenzal-dehyde with the same heterocyclic ammonium bases as have been used in the synthesis of the compounds described in this paper) the properties of the latter have been collected from relevant publications and summarised in Table II. It will be seen that with the exception of the α-naphthathiazole derivative, the dimethylamino compound in every case, has a higher m.p. than the corresponding diethylamino compound, notwithstanding the increased molecular weight of the latter. In the matter of photographic sensitisation the two simple thiazole derivatives of *p*-diethylaminobenzaldehyde (V) and (W) are slightly more powerful than the corresponding dimethylamino compounds. The three condensed thiazole derivatives (X), (Y) and (Z), however, are much less powerful than the corresponding dimethylamino compounds.

EXPERIMENTAL

2 : 4-*Dimethylthiazole-methiodide.*—2 : 4-Dimethylthiazole was prepared according to the method of Hantsch (*Annalen*, 1889, **250**, 270) and obtained in a yield of 58.4% (Hantsch does not record the yield of his compound). It was quaternised by Hamer's method (*J. Chem. Soc.*, 1930, 2509) and was obtained as pink needles even after five recrystallisations with m.p. 268° (Hamer's crystals were colourless and had m.p. 260°). (Found : I, 50.05. $C_6H_{10}NIS$ requires I, 49.8 per cent).

2-p-*Diethylaminostyryl-4-methylthiazole-methiodide* (V).—*p*-Diethylaminobenzaldehyde (0.72 g.) and 2 : 4-dimethylthiazole-methiodide (1.02 g.) were dissolved in acetic anhydride (15 c.c.) and the solution refluxed for 4 hours. The reaction started even in the cold, as was indicated by the change in the colour of the solution. The red solution was concentrated to about half its volume and then left for 4 days. The separated crystals (0.4 g.) were recrystallised from absolute methyl alcohol, yield 0.2 g. (12.1%). (Found : N, 6.87 ; I, 30.50. $C_{17}H_{23}N_2IS$ requires N, 6.76 ; I, 30.67 per cent).

4-*Phenyl-2-methylthiazole-methiodide.*—4-Phenyl-2-methylthiazole was prepared from acetamide and phenacyl bromide as described by Hantsch (*loc. cit.*), and was converted into its methiodide by the method of Mills and Smith (*J. Chem. Soc.*, 1922, **121**, 2735). It was obtained in the form of slightly reddish crystals, the colour of which deepened on keeping, melting at 200° (Mills and Smith give m.p. 202°). The yield of the base was 80% and that of the methiodide 50% (neither Hantsch nor Mills and Smith record the yields of their compounds).

2-p-*Diethylaminostyryl-4-phenylthiazole-methiodide* (W).—*p*-Diethylaminobenzaldehyde (0.54 g.), 4-phenyl-2-methylthiazole-methiodide (0.96 g.), absolute alcohol (10 c.c.) and piperidine (5 drops) were heated together for 3 hours. The reaction mixture was

placed in a frigidaire overnight and the separated crystals (1.0 g.) recrystallised from methyl alcohol, yield 0.9 g. (62.5%). (Found : N, 6.02 ; I, 26.31. $C_{22}H_{25}N_2IS$ requires N, 5.88 ; I, 26.68 per cent).

2-Methylbenzothiazole-methiodide.—This compound has been mentioned by Smith (*J. Chem. Soc.*, 1923, **123**, 2292) but the details of the preparation have not been given. We obtained it by heating 2-methylbenzothiazole (1 mol.), prepared by oxidising thio-acetamide with potassium ferricyanide (Jacobson, *Ber.*, 1886, **19**, 1072 ; Clark, *J. Chem. Soc.*, 1928, 2313 ; Guha and Ghosh, *J. Indian Inst. Sci.*, 1929, **12**, 34) and methyl iodide (1.5 mol) in a sealed tube for 24 hours. The resulting white crystalline mass was recrystallised from rectified spirit. The methiodide consists of colourless plates, m.p. 219°. (Found : I, 43.92. $C_9H_{10}NIS$ requires I, 43.64 per cent).

2-p-Diethylaminostyryl-benzothiazole-methiodide (X).—On heating a solution of 2-methyl-benzothiazole-methiodide (0.58 g.) and *p*-diethylaminobenzaldehyde (0.36 g.) in absolute alcohol (8 c.c.) with piperidine (0.1 c.c.), a red colour developed immediately. After boiling for one hour and cooling, crystals of the dyestuff were deposited (0.57 g.). These were recrystallised from methyl alcohol, yield 0.48 g. (53.9%). (Found : N, 6.56 ; I, 28.02. $C_{20}H_{23}N_2IS$ requires N, 6.22 ; I, 28.22 per cent).

2-p-Diethylaminostyryl-α-naphthathiazole-methiodide (Y) —2-Methyl-α-naphthathiazole-methiodide (Jacobson, *Ber.*, 1888, **21**, 2627 ; Hamer, *J. Chem. Soc.*, 1929, 2602) (2.05 g.), *p*-diethylaminobenzaldehyde (1.08 g.), absolute alcohol (15 c.c.) and piperidine (6 drops) were boiled together for a couple of hours. The dyestuff began to separate from the boiling solution. The mixture was allowed to cool, the crystals filtered, washed with ether and recrystallised from methyl alcohol, yield, 1.25 g. (41.6%). (Found : N, 5.69 ; I, 25.29. $C_{24}H_{25}N_2IS$ requires N, 5.60 ; I, 25.40 per cent).

2-p-Diethylaminostyryl-β-naphthathiazole-methiodide.—On refluxing 2-methyl-β-naphthathiazole-methiodide (Jacobson, *Ber.*, 1887, **20**, 1897 ; Hamer, *J. Chem. Soc.*, 1929, 2601) (0.68 g.), *p*-diethylaminobenzaldehyde (0.36 g.), absolute alcohol (7.5 c.c.) and piperidine (0.3 c.c.), for 3 hours the dye was deposited. The ether-washed crystals were recrystallised from methyl alcohol, yield, 0.6 g. (60.0%). (Found : N, 5.72 ; I, 25.37. $C_{24}H_{25}N_2IS$ requires N, 5.60 ; I, 25.40 per cent).

One of us (J. C. B.) is indebted to the authorities of the Patna University for a re-search scholarship, which he desires gratefully to acknowledge.

SYNTHESIS IN THE ACRIDINE SERIES. PART I. N-SUBSTITUTED-2-METHOXY-5-CHLORO-9-AMINOACRIDINES

By Gurbakhsh Singh and Mahan Singh

N-substituted 2-methoxy-5-chloro-9-aminoacridines have been described. 2-Methoxy-5-chloroacridine and 2-methoxy-5-chloro-9-aminoacridine have also been prepared.

The use of acridine derivatives as antimalarials was first marked by Mauss and Mietzsch (*Klin. Woch.*, 1933, **12**, 1276), who introduced Atebrin [2-methoxy-6-chloro-9(ω-diethylamino-*iso*amylamino) acridine dihydrochloride]. Magidson and Grigorowski (*Chim. Farm. Prom.* No. I, 26) later prepared acriquine [2-methoxy-6-chloro-9 (γ-diethylaminopropyl) aminoacridine dihydrochloride] which also was found to be equally potent. Since then a great number of acridine compounds have been synthesised. Amongst these, the various 9-aminoacridines, especially those with a basic substituent in the amino group are of therapeutic importance, particularly from the standpoint of antimalarial value.

Magidson and Grigorowski (*Ber.*, 1936, **61**, 396) have established that the presence of both methoxy and chloro groups in the acridine nucleus is essential for the development of antimalarial properties. When either of the groups is absent, the compound is devoid of antimalarial value. Feldmann and Kopelivitoch (*Arch. Pharm.*, 1935, **273**, 488) have shown that by the transfer of chlorine atom from position 6 to 7, the antimalarial activity is considerably reduced. No information is as yet available as to the antimalarial characteristic of chlorine atom at position 5 or 8. Similarly it would be of interest to ascertain how the antimalarial properties are affected by shifting the methoxy group from position 2 to that at 1, 3 or 4 in the acridine molecule.
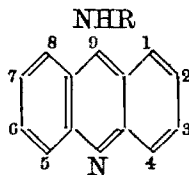
It was therefore decided to attempt the preparation and to investigate the antimalarial properties of basically N-substituted derivatives of the sixteen possible methoxy-chloro-9-aminoacridines, out of which fourteen are unknown.

The present paper deals with the preparation of various N-substituted 2-methoxy-5-chloro-9-aminoacridines.

2-Bromo-5-methoxybenzoic acid has been condensed with o-chloroaniline to give 6'-chlorodiphenylamine-4-methoxy-2-carboxylic acid, which on treatment with excess of phosphoryl chloride is converted into 2-methoxy-5 : 9-dichloroacridine. This is condensed with seven dialkylamino alkylamines, sulphanilamide and arsanilic acid. The various 2-methoxy-5-chloro-9(diaklylamino-alkyl) aminoacridines are better obtained through the 6'-chlorodiphenylamine-4-methoxy-2-carboxyl chloride (*cf.* E.P., 364, 392 ; Goodall and Kermack, *J. Chem. Soc.*, 1936, 1546 ; and also Drozdov, *J. Gen. Chem.* U.S.S.R., 1938, **8**, 1192). The reaction proceeds very smoothly and excellent yields are obtained.

2-Methoxy-5-chloroacridone and 2-methoxy-5-chloro-9-aminoacridine have also been described.

The various condensation products show strong fluorescence in dilute alkali, alcohol, acetone or ether.

Experimental

2-Bromo-5-methoxybenzoic Acid.—*m*-Methoxybenzaldehyde, obtained by methylation of *m*-hydroxybenzaldehyde (Tiemann, *Ber.*, 1882, **15**, 2048) on bromination gave 2-bromo-5-methoxybenzaldehyde which was oxidised to 2-bromo-5-methoxybenzoic acid (Pschorr, *Annalen*, 1901, **391**, 26).

4-Methoxy-6'-chlorodiphenylamine-2-carboxylic Acid.—Dry 2-bromo-5-methoxybenzoic acid (23.1 g., 1 mol.) was added to a solution of potassium (1 atom) in methyl alcohol (30 c.c.) and then freshly distilled *o*-chloroaniline (19.2 g. 1.5 mols) was added. Copper powder (0.1 g.), CuCl (0.1 g.) and *iso*amyl alcohol (30 c.c.) were added and the reaction mixture was heated in an oil-bath at 140° for 2-3 hours and methyl alcohol allowed to evaporate off slowly from a short air condenser. Excess of *iso*amyl alcohol was then distilled off and the last traces removed by passing steam. The residue after being made acidic to Congo red was crushed to a green powder. It was extracted with potassium bicarbonate (charcoal) and decomposed with hydrochloric acid yielding a voluminous yellow mass. After drying, it was crystallised from glacial acetic acid as bright yellow needles, m.p. 186°-88°, yield 75%. It is soluble in ether, chloroform, hot benzene and toluene. (Found : N, 4.95. $C_{14}H_{12}O_3NCl$ requires N, 5.04 per cent).

4-Methoxy-6'-chlorodiphenylamine-2-carboxyl Chloride.—Phosphorous pentachloride (2.30 g., 1.1 mol) was added to a suspension of 4-methoxy-6'-chlorodiphenylamine-2-carboxylic acid (2.78 g., 1 mol) in absolute petroleum ether (40-60°, 80 c.c.) and the reaction mixture refluxed on a water-bath for about 20 minutes, when a clear yellow solution was obtained. This was filtered and the filtrate on cooling deposited a yellow mass. This was filtered and washed with a little petroleum ether. Finally it was crystallised from low-boiling absolute petroleum ether as long orange yellow needles, m.p. 112°, yield 70%. (Found : N, 4.63. $C_{14}H_{11}O_2NCl$ requires N, 4.73 per cent).

2-Methoxy-5 : 9-dichloroacridine.—4-Methoxy-6'-chlorodiphenylamine-2-carboxylic acid (5 g.) was refluxed with phosphoryl chloride (40 c.c.) for about 4 hours at 130°. Excess of phosphoryl chloride was removed under vacuum and the yellow sticky residue was taken up in chloroform (40 c.c.). The solution was cooled externally in ice and treated with an excess of 10% ice-cold ammonia solution. The chloroform layer was thoroughly washed with water and then dried over anhydrous sodium sulphate. Chloroform was distilled off and the residue was crystallised from absolute ethyl acetate (charcoal) as beautiful yellow plates, m.p. 157-58°, yield 85%. It shows a strong bluish fluorescence in ethyl acetate. (Found : N, 5.20. $C_{14}H_9ONCl_2$ requires N, 5.03 per cent).

γ-Diethylaminopropylamine, γ-di-*n*-propylaminopropylamine, γ-di-*n*-butylamine-propylamine, γ-di-*n*-amylaminopropylamine and γ-piperidinopropylamine, were each prepared by the reduction of their corresponding nitrile obtained by the interaction of acrylic nitrile and the appropriate secondary amine (Adam *et al.*, *J. Amer. Chem. Soc.*, 1944, **66**, 727). While Adam and co-workers have carried out the catalytic reduction

of these nitriles with only moderate yields, we have carried out these reductions by sodium and absolute ethanol with much higher yields. In each case the product was characterised by its picrate. The following general method has been used for the reduction of basically substituted nitriles.

Sodium (cut into small pieces, 10g.) was added slowly with continuous shaking to a solution of the nitrile (10 g.) in absolute ethanol (250 c.c.) kept boiling on a water-bath. After cooling, the reaction mixture was saturated with dry hydrochloric acid gas. Sodium chloride was filtered off and washed with a little absolute ethanol. The combined filtrates were fractionated under vacuum. After all the alcohol had been removed, the residue in the flask was decomposed with 50% sodium hydroxide solution and extracted with ether. The ethereal extract was dried (fused magnesium sulphate), ether was distilled off and the residue distilled under vacuum. The products were in each case free from the corresponding secondary amines, a common impurity obtained during the catalytic reduction. γ-Diethylaminopropylamine was obtained in 78% yield against that of 54% by Adam and co-workers (loc. cit.). It may be noted here that Hamilton and Utermohlen (J. Amer. Chem. Soc., 1941, 63, 156) who tried the reduction of γ-diethyl-aminopropionitrile with sodium in toluene and water, have reported negative results. γ-Di-n-butylaminopropylamine was obtained in 75% yield (Adam and co-workers give 32% yield). Burckhalter and co-workers (J. Amer. Chem. Soc., 1943, 65, 2012) give 70%. γ-Di-n-amylaminopropylamine was obtained in 68% yield (Adam and co-workers give 47%). γ-Piperidinopropylamine was obtained in 88% yield, against that of 68.5% by Adam and coworkers.

2-Methoxy-5-chloro-9-(γ-diethylaminopropyl)-aminoacridine.—γ-Diethylaminopropylamine (1.5 g.) was added slowly to a solution of 2-methoxy-5:9-dichloroacridine (3 g.) in phenol (12 g.). The reaction mixture was heated at 100-110° for 3 hours. After cooling, the contents were poured into excess of 2N-sodium hydroxide solution and the product extracted with ether. The ethereal solution was shaken with 25 c.c. of 5% acetic acid and aqueous layer removed. It was filtered from any suspended acridone and decomposed with alkali. The yellow base was extracted with ether and ethereal extract dried over fused potassium carbonate. The dihydrochloride of the condensation product was precipitated by addition of alcoholic hydrochloric acid. The semi-solid dihydrochloride, so obtained, was twice crystallised from a mixture of absolute alcohol and ether as a deep yellow powder. It was dried in an air-oven at 100° for 3 hours, m.p. 240-42° (decomp.), yield 50%. It is freely soluble in water and alcohol. (Found : N, 9.40. $C_{21}H_{26}ON_3Cl$, 2HCl requires N, 9.44 per cent).

The same compound was obtained in 75% yield, when the reaction was carried through the acid chloride.

A solution of 4-methoxy-6'-chlorodiphenylamine-2-carboxyl chloride (2.80 g., 1 mol.) in absolute benzene (20 c.c.) was treated with γ-diethylaminopropylamine (1.35 g., 1 mol.). The yellow solution at once changed to a colourless syrup. The mixture was warmed for 10 minutes on a water-bath and benzene was then removed under vacuum. The residual oil was refluxed with phosphoryl chloride (5 c.c.) for about 2 hours, after which excess of phosphorous oxychloride was removed under vacuum. The yellow product dissolved in water to give a clear solution. No insoluble acridone was obtained. It

was decomposed with alkali and the base extracted with ether and converted into di-hydrochloride as described above.

2-Methoxy-5-chloro-9-(γ-*diethylaminobutyl*) *aminoacridine* was obtained by either of the two methods described above, by the condensation of 2-methoxy-5 : 9-dichloro-acridine and δ-diethylaminobutylamine (Strukove, *Khim. Farm. Prom.*, 1933, 332).

The dihydrochloride was twice crystallised from a mixture of absolute ethanol and ether as a yellow powder, m.p. 245-47° (decomp.). (Found : N, 9.12. $C_{22}H_{28}ON_3Cl$, 2HCl requires N, 9.16 per cent).

2-Methoxy-5-chloro-9-(ε-*diethylaminoamyl*) *aminoacridine* was obtained by the condensation of 2-methoxy-5 : 9-dichloroacridine and ε-diethylaminoamylamine (Magidson *Ber.*, 1936, **69**, 396). The dihydrochloride could not be crystallised as an oil always separated on the addition of ether to the alcoholic solution. It is very soluble in water and alcohol. The dipicrate was prepared in benzene solution and crystallised from absolute ethanol as yellow needles, m.p. 180-82°. [Found : N, 15.01. $C_{23}H_{30}ON_3Cl$, $2(C_6H_3N_3O_7)$ requires N, 14.69 per cent].

2-Methoxy-5-chloro-9-(γ-*di*-n-*propylaminopropyl*) *aminoacridine.*—The dihydrochloride was crystallised from a mixture of absolute alcohol and ether as a yellow powder, m.p. 308-10°. It was dried in an air-oven at 100° for 3 hours. (Found : N, 8.55. $C_{23}H_{30}ON_3Cl$, 2HCl requires N, 8.88 per cent).

2-Methoxy-5-chloro-9-(γ-*di*-n-*butylaminopropyl*) *aminoacridine.*—The dihydrochloride was twice crystallised from a mixture of absolute ethanol and ether as a yellow powder. It melted above 310° with decomposition and previous darkening. (Found : N, 8.55. $C_{25}H_{34}ON_3Cl$, 2HCl requires N, 8.39 per cent).

2-Methoxy-5-chloro-9-(γ-*di*-n-*amylaminopropyl*) *aminoacridine.*—The dihydrochloride was crystallised from absolute alcohol as light yellow glistening leafy plates, which exhibit green fluorescence in alcohol. It darkens at 300° and melts with decomposition at 325-27°. (Found : N, 7.62. $C_{27}H_{30}ON_3Cl$, 2HCl requires N, 7.95 per cent).

2-Methoxy-5-chloro-9-(γ-*piperidinopropyl*) *aminoacridine dihydrochloride* was crystallised from a mixture of absolute alcohol and ether as a yellow powder, m.p. 253-55° (decomp.). It is soluble in water and alcohol. (Found : N, 9.23. $C_{22}H_{26}ONCl_3$, 2HCl requires N, 9.20 per cent).

2-Methoxy-5-chloro-9-(p'-*sulphanilaminophenyl*) *aminoacridine.*—A solution of 2-methoxy-5 : 9-dichloroacridine (2.78 g., 1 mol.) in phenol (8 g.) was treated with *p*-aminobenzene-sulphonamide (1.72 g., 1 mol.). The mixture was heated at 100° for 3 hours. After cooling, it was diluted with ether (50 c.c.) and the yellow hydrochloride of the condensation product was filtered and washed with ether. It was then triturated with 15% cold ammonia solution. The orange product obtained, after drying, was crystallised from absolute alcohol as orange needles, which turn yellow on heating, m.p. 250-51°. (Found : N, 10.10. $C_{20}H_{16}O_3N_3ClS$ requires N, 10.15 per cent).

2-Methoxy-5-chloro-9-(p'-*arsonophenyl*) *aminoacridine.*—A solution of 2-methoxy-5 : 9-dichloroacridine (2.78 g., 1 mol.) in phenol (8 g.) was treated with *p*-arsanilic acid (2.17 g., 1 mol.) and the reaction mixture heated at 100-110° for 3 hours. After cooling, it was diluted with ether (70 c.c.) and the orange product, so obtained, was collected on suction and thoroughly washed with it. It was then washed with boiling water to remove any

uncondensed arsanilic acid. The condensation product was dissolved in 5% potassium hydroxide solution and filtered free of any acridone. It was decomposed with dilute acetic acid and then recrystallised from glacial acetic acid as stout orange needles, m.p. 257-59° (decomp.). (Found : N, 5.92. $C_{20}H_{16}O_4N_2ClAs$ requires N, 6.10 per cent).

2-*Methoxy-5-chloroacridone.*—2-Methoxy-5 : 9-dichloroacridine (0.2 g.) was refluxed with hydrochloric acid (20 c.c., 5 g.) for about 30 minutes, when the yellow acridine changed slowly into white acridone. It was filtered and recrystallised from glacial acetic acid as colourless needles, m.p. 269-70°. It shows a bluish fluorescence in acetic acid. (Found : N, 5.45. $C_{14}H_{10}O_2NCl$ requires N, 5.39 per cent).

2-*Methoxy-5-chloro-9-aminoacridine.*—A solution of 2-methoxy-5 : 9-dichloroacridine (2 g.) in phenol (15 g.) was treated with ammonium carbonate (1.5 g.) at 70° and the temperature raised to 130°, and maintained for 15 minutes. After cooling, the reaction mixture was diluted with ether (80 c.c.) and dry hydrochloric acid gas was passed into the mixture, when the hydrochloride separated out. It was filtered and washed successively with ether and acetone. The hydrochloride was decomposed with dilute sodium hydroxide solution and the yellow product so obtained was crystallised from a mixture of ethanol and acetone as deep yellow glistening needles, m.p. 230-32°. It is soluble in acetic acid with a strong bluish green fluorescence which persists even on dilution. (Found : N, 10.78. $C_{14}H_{11}ON_2Cl$ requires N, 10.83 per cent).

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QUINOLINE DERIVATIVES. PART XIII

By S. Banerjee and T. N. Ghosh

The synthesis of 2-hydroxy-4-methylquinoline-6-arsonic acid is described.

Organic arsenicals have proved valuable in the treatment of syphilis, trypanosomiasis and amoebiasis. Some also have been found to possess antimalarial properties. In a previous communication it has been pointed out that compounds containing both the quinoline nucleus and arsenic in their molecule would seem to offer good possibilities of having therapeutic value in chronic malaria.

The classical method of Knorr (*Annalen*, 1886, **236**, 75) and that of Conrad and Limpach (*Ber.*, 1887, **20**, 944) have now been applied for the synthesis of some new quinoline-arsonic acid derivatives.

When *para*-arsanilic acid is allowed to react with ethyl acetoacetate at 160-165°, a mixture of *p*-acetoacetylaminophenylarsonic acid (I) and ethyl β-[phenyl-(4-arsonic acid) amino] crotonate (II) is obtained.

$$Me.CO.CH_2.CONH.\langle\quad\rangle. AsO(OH)_2 \qquad Me.C(:CH.CO_2Et).NH.\langle\quad\rangle.AsO(OH)_2$$

$$(I) \qquad\qquad\qquad\qquad (II)$$
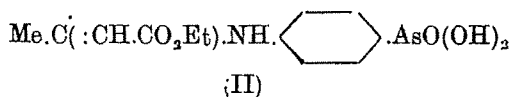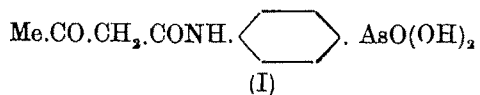
The compound (I), which contains a ketonic group, reacts with phenylhydrazine to yield the phenylhydrazine salt of the corresponding phenylhydrazone.

It is interesting to note that the sodium salt of the compound (I) is structurally related to Tryparsamide (III) and Neocryl (IV).

$$NH_2.CO.CH_2.NH.\langle\quad\rangle. AsO\langle^{ONa}_{OH} \qquad Me.NH CO.(CH_2)_2.CO.NH\langle\quad\rangle. AsO\langle^{ONa}_{OH}$$

$$(III) \qquad\qquad\qquad\qquad (IV)$$
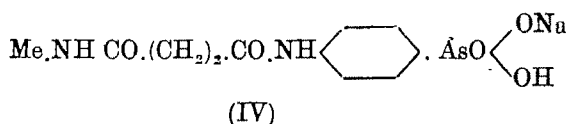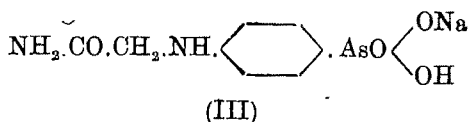
Some claims have been made that Neocryl is less toxic to the optic nerve than Tryparsamide and possibly more effective in neurosyphilis (*cf.* Murgatroyd, *Ann. Trop. Med.*, 1937, **31**, 472 ; Lum, *Chem. Products*, 1939, **2**, 99 ; Acres, *Trans. Roy. Soc. Trop. Med. Hyg.*, 1940, **34**, 281). Both (III) and (IV) are derivatives of *para*-arsanilic acid and both contain the -CO.NH- group. The question naturally arises as to whether the grouping, -CO.NH-, has any special significance in connection with the activity of these drugs, since some amide-substituted phenylarsine oxides also have been recently found to show high chemotherapeutic index in the treatment of rabbit syphilis (*cf.* Eagle, Hogan, Doak and Steinman, *J. Amer. Chem. Soc.*, 1943, **65**, 1236). It will therefore be worth while to see if the compound (I) has any effect on trypanosomiasis and also on neurosyphilis.

When the compound (I) is treated with concentrated sulphuric acid at 60°, the quinoline-arsonic acid derivative (VI) is obtained (*cf.* Knorr, *loc. cit.*). Whereas the compound (I) gives a deep red colouration with ferric chloride and a phenylhydrazone (V), the com-

pound (VI) does neither give any distinctive colouration with ferric chloride nor any phenylhydrazone.

(VI)
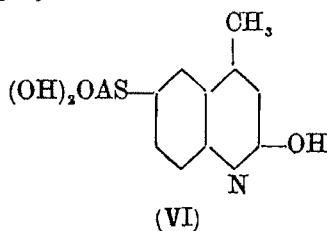
The cyclisation of the compound (II), which does not melt even at 300°, with concentrated sulphuric acid at room temperature was attempted but the product isolated could not be purified, due to its insolubility in organic solvents and also in hot water.

EXPERIMENTAL

Condensation of Ethyl Acetoacetate with p-*Arsanilic Acid* : *Formation of* p-*Acetoacetyl-aminophenylarsonic Acid* (I) *and Ethyl* β-[*Phenyl-(4-arsonic acid) amino*] *crotonate* (II).— p-Arsanilic acid (100 g.) and ethyl acetoacetate (30 g.) were thoroughly mixed together and heated in an oil-bath at 160-165° for 20 hours. The residual liquid was then distilled off under reduced pressure and the solid left was cooled, thoroughly triturated with excess of dilute hydrochloric acid to remove the unreacted p-arsanilic acid, filtered and thoroughly washed with water. The mass was next purified by solution in aqueous sodium carbonate and reprecipitation with excess of dilute hydrochloric acid. The solid obtained was dried and extracted twice with boiling alcohol and filtered. A portion went into solution, leaving some quantity which was found insoluble in boiling alcohol.

The alcoholic solution, on evaporation, left a residue (compound I) which was twice crystallised from 50% alcohol (charcoal) in brown crystalline powder (10 g.) which does not melt even at 300°. (Found : N, 4.34 ; As, 24.68. $C_{10}H_{12}O_5NAs$ requires N, 4.65 ; As, 24.91 per cent). An alcoholic solution of this compound (I) gives a deep red colouration with ferric chloride.

The portion (compound II), found insoluble in boiling alcohol, was washed several times with hot alcohol. It was found insoluble in boiling water and in ordinary organic solvents, and was purified by solution in aqueous sodium carbonate and precipitation with dilute hydrochloric acid. On drying the compound (II) was obtained as a brown crystalline powder (yield 5 g.), which does not melt even at 300°. (Found : N, 4.17 ; As, 23.20. $C_{12}H_{16}O_5NAs$ requirse N, 4.25 ; As, 22.76 per cent).

p-(*Acetophenylhydrazone-acetylamino*)-*phenylarsonic Acid* (V).—To a hot alcoholic solution of the compound (I ; 10 g.) phenylhydrazine (10 g.) was added, and the solution was then heated under reflux on the wire-gauze for about 2 hours, when a brown crystalline solid was precipitated. It was filtered and washed thoroughly with hot alcohol and then with ether. It is sparingly soluble in hot alcohol and practically insoluble in hot water. It was crystallised from large quantity of alcohol in brownish rectangular plates, which do not melt even at 300°. It is insoluble in aqueous sodium bicarbonate and is the phenylhydrazine salt of compound (V). [Found : N, 15.93. $C_{16}H_{18}O_4N_3As$ (2PhNH-NH₂) requires N, 16.14 per cent].

The above salt is, however, soluble in cold dilute caustic soda solution and the alkaline solution, on acidification with excess of dilute hydrochloric acid in the cold, precipitated a brownish solid (compound V ; yield 5 g.) which does not melt even at 300°. (Found : N, 10.58 ; As, 18.72. $C_{16}H_{18}O_4N_3As$ requires N, 10.74 ; As, 19.18 per cent).

2-Hydroxy-4-methylquinoline-6-arsonic Acid (VI).—Concentrated sulphuric acid (15 c.c.) was slowly added to the above compound (I ; 5 g.), when gradually, on shaking, a thick clear solution was obtained with slight rise in temperature. The solution was then heated in an oil-bath at 60° for 3 hours and then allowed to stand overnight. Next day the solution was poured into ice-water under stirring, when a dark solid was precipitated. This substance is soluble in hot alcohol but it did not show any tendency to crystallise from alcohol. It was, however, purified twice by adding excess of ether to an alcoholic solution of the substance, when an amorphous mass was precipitated, which on standing for about 30 minutes turned into a chocolate-coloured crystalline powder (yield 2 g.), which does not melt even at 300°. (Found : N, 5.28 ; As, 26.02. $C_{10}H_{10}O_4NAs$ requires N, 4.94 ; As, 26.50 per cent). With ferric chloride an alcoholic solution of this substance does not give any distinctive colouration but gives a brown precipitate. It does not form any phenylhydrazone.

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BISMUTH IODIDE COMPLEXES OF SOME 8-HYDROXYQUINOLINE DERIVATIVES

BY S. L. LASKAR

For pharmacological study against amoebiasis, bismuth iodide complexes of 8-hydroxyquinoline, 5-chloro-8-hydroxyquinoline, 5 : 7-dichloro-8-hydroxyquinoline, 7-iodo-5-chloro-8-hydroxyquinoline and 5 : 7-di-iodo-8-hydroxyquinoline have been prepared.

In recent years compounds like 7-iodo-8-hydroxyquinoline (Vioform) and 5 : 7-di-iodo-8-hydroxyquinoline (Diodoquin) have proved extremely useful in the treatment of chronic and relapsing cases of amoebic dysentery. Emetine bismuth iodide and Kurchi bismuth iodide have also been found to be useful in the treatment of chronic amoebic dysentery. However, as a result of extensive clinical trials of these and other important chemotherapeutic drugs on cases of amoebic dysentery in the army in India, Leishman and Kelsall (*Lancet*, 1944, p. 231) have found that there are some relapsing cases which resist the action of all these drugs or a combination of some of them. They have felt the urgent need for the discovery of a new, more potent amoebicidal drug which will effect cure in chronic and relapsing cases.

In the search for an ideal amoebicidal drug, bismuth iodide complexes of some halogen derivatives of 8-hydroxyquinoline have now been prepared and characterised. They have been prepared by the interaction of a cold, freshly prepared Draggendroff's reagent with the hydrochloric acid solution of requisite quantity of the respective halogen derivative of 8-hydroxyquinoline. All these complex salts are of deep orange colour, soluble in acetone and have definite melting points.

The analyses of the component parts of these complexes have been carried out according to the process adopted in the standardisation of Kurchi bismuth iodide (Mukherjee, *J. & Proc. Inst. of Chem., India*, 1944, **16**, 64), slightly modified. In the estimation

of iodine, chloroform has been used in place of alcohol, as the halogenated derivatives of 8-hydroxyquinoline are less soluble in alcohol than in chloroform.

A study of the data recorded in the Table I (*vide* Experimental) reveals the nature of the composition of these complexes. The percentages of the respective quinoline derivative, bismuth and iodine, as found by analyses, conform to the composition, Q.HI. BiI$_3$, where Q stands for the corresponding quinoline derivative (*cf.* Quinine bismuth iodide, Franquin and Seguin, *J. Pharm. Chim.*, 1925, VIII, I, 525). Moreover, it has been shown by Berg and Wurm (*Ber.*, 1927, 60, 1664) that in the estimation of bismuth by using 8-hydroxyquinoline in presence of sulphuric acid and potassium iodide, the complex that separates has also the composition Q.HI.BiI$_3$. In this connection it may be mentioned that the composition of these complexes, however, differs from that of Kurchi bismuth iodide, which is of the type, B.2HI.BiI$_3$, where B stands for the base (Mukherjee, *loc. cit.*).

EXPERIMENTAL

The general procedure followed in the preparation of the bismuth iodide complexes of derivatives of 8-hydroxyquinoline is given below in case of one particular preparation. The results of analyses and melting points of other derivatives are summarised in Table I.

8-Hydroxyquinoline-bismuth Iodide.—Pure 8-hydroxyquinoline (2 g.) was dissolved in 10% hydrochloric acid (100 c.c.) and the solution was stirred with kaolin for about 30 minutes to remove the colouring matter. After filtration the solution was cooled and to this was slowly added, with constant stirring, freshly prepared, cold Draggendroff's reagent, till the precipitation of an orange-coloured solid was complete. This was filtered, washed several times with water till the filtrate was clear and finally washed with alcohol, dried on the water-bath, m.p. 270-75°; yield 8 g. It is readily soluble in acetone.

TABLE I

Substances	M.p.	% of corresponding quinoline derivatives		% of Bismuth		% of Iodine	
		Found.	Calc.	Found.	Calc.	Found.	Calc.
8-Hydroxyquinoline bismuth iodide	270-275°	17.00	16.80	24.10	24.21	58.77	58.89
5-Chloro-8-hydroxyquino-line bismuth iodide	225-230°	19.98	20.01	23.32	23.30	56.32	56.69
5 : 7-Dichloro-8-hydroxy-quinoline bismuth iodide	212-215°	23.01	22.96	22.25	22.42	54.51	54.62
7-Iodo-5 chloro-8-hydroxy-quinoline bismuth iodide	190-195°	29.38	29.86	20.61	20.43	50.01	49.71
5 : 7-Diiodo-8-hydroxy-quinoline bismuth iodide	above 300°	34.77	35.60	18.81	18.74	46.42	45.66

My thanks are due to Dr. T. N. Ghosh for his suggestion in course of this investigation.

STABILITY OF VITAMIN-A IN SESAME OIL

BY S. SEN-GUPTA

Vitamin A in vitaminised sesame oil is rapidly destroyed.

While investigating on the extraction of vitamin-A from fishliver oils, recourse was taken to various vegetable oils such as groundnut, sesame oil etc. By this process the vitamin-A is transferred from the liver oil to the vegetable oils. But the oil should be such as to retain the vitamin for a long time and as such should be examined for its retentive capacity. The stability of vitamin-A in arachis oil and olive oil has been studied by Basu (*Ann. Biochem. Expt. Med.*, 1941, **1**, 165, *cf.* also Basu and Sen-Gupta, *Curr. Sci.*, 1941, **10**, 288). But as sesame oil was also used in the above work, an investigation was undertaken to ascertain the keeping properties of vitamin-A in sesame oil. A variety of sesame oil from the market was analysed for its acid, peroxide and iodine values. Acid value, 10 ; peroxide value, 7 (expressed in terms of c.c. of 0.002 N-thiosulphate) ; iodine value, 107.

As the oil contained a large amount of free acid it was purified in the usual way *i.e.* by means of a solution of sodium carbonate as follows :

The oil was treated with sufficient amount (as determined by the acid value of the sample under consideration) of a concentrated solution of sodium carbonate to neutralise the free acid present. The soap formed was removed first by filtration and finally by extraction with alcohol (95%). The oil was then dried over sodium sulphate and heated to 150° in an oil-bath for half an hour under vacuum to remove the last traces of moisture.

The oil thus purified was found to have the following characteristics : Acid value, 0.5 ; peroxide value, 6.0. Thus it was noticed that the treatment did not help in lowering the peroxide value of the original oil to any appreciable extent. This was, however, taken for the study on the stability of vitamin-A.

The oil was mixed with a known concentrate of vitamin-A in such a way that the finished product contained approximately 1000 I.U. of vitamin-A per g., and the potency was measured in terms of Carr-Price blue value which was found to be 10.2. The vitaminised oil thus obtained, was subjected to aeration in a glass bottle closed with a velvet cork with two borings for inlet and outlet tubes. Air previously purified by passing through concentrated sulphuric acid and soda lime was bubbled through the oil placed in the bottle at room temperature. Vitamin-A concentrate was determined by the Carr-Price method. The results are recorded in Table I.

TABLE I

Period of aeration.	Blue value.	Peroxide value.	Acid value.
0 hrs.	10.2	6.0	0.5
10	9.4	8.5	0.5
20	8.3	11.0	0.5
36	Trace	50.0	0.6

It may be noticed from the table that the vitamin present in the oil was gradually being destroyed and after aeration for 36 hours, no trace of it was noticed as measured

by C.P. blue value method. With the aeration the peroxide value has also increased from 6 to 50 whereas there is no appreciable increase in its acid value. It may be mentioned here that the iodine value of sesame oil is nearer to that of arachis oil whose iodine value generally varies from 85 to 99. But the rate of formation of peroxide in the former case is considerably enhanced and consequently the destruction of vitamin-A in this oil is much rapid when compared to similar destruction of vitamin-A concentrate dissolved in arachis oil as noted by Basu (*loc. cit.*) and Basu and Sen-Gupta (*loc. cit.*). For such rapid destruction of vitamin no other experiment was conducted after incorporation of any suitable antioxidant. It may be noted that the use of antioxidants would retard the peroxide formation as also the rate of destruction of vitamin-A, but since it is obvious from the observations made in this laboratory that in sesame oil peroxide formation is much faster than in arachis oil which is also easily available, it was not considered to be of any practical value to try the effect of antioxidants for this work.

The author wishes to express his thanks to Dr. U. P. Basu for his help and suggestion.

STUDIES IN FRIES MIGRATION. PART II. THE FRIES MIGRATION OF ESTERS OF 7-HYDROXY-3-ALKYL-4-METHYL-6-ETHYLCOUMARINS

By V. M. THAKOR AND N. M. SHAH

The Fries rearrangement of the esters of 7-hydroxy-3-alkyl-4-methyl-6-ethylcoumarins has been studied. It is observed that the alkyl groups exert but little influence on the course of the migration. The migration products have been subjected to Kostanecki acetylation and various coumarino-a- or γ-pyrones are formed.

In continuation of our work described in the previous part of this series (*J. Indian Chem. Soc.*, 1946, 23, 199) we have investigated the Fries rearrangement of different esters of 7-hydroxy-4-methyl-6-ethyl- as well as of 7-hydroxy-3-alkyl-4-methyl-6-ethyl-coumarins. The results obtained confirm our previous conclusions that (1) below a certain temperature the migration does not take place : and, if the migration is carried out at higher temperature, the product gets charred (*cf.* Tarbell and Fanta, *J. Amer. Chem. Soc.*, 1943, 65, 2169) ; (2) different acyl groups require different temperatures for migration, which vary according to the nature and size of the acyl group, *e.g.*, benzoyl group requires a higher temperature for migration than the acetyl (Rosenmund and Schnurr, *Annalen*, 1928, 460, 56 ; Baltzly and Bass, *J. Amer. Chem. Soc.*, 1933, 55, 4292) and (3) the use of aluminium chloride in proportions higher than three moles leads to the contamination of the resulting products with impurities.

In all cases, the migration was smooth and the different substituents present in the coumarin nucleus had little inhibitory influence on the course of the rearrangement. In all cases, the product obtained was found to be 7-hydroxy-3-alkyl-4-methyl-6-ethyl-8-acetyl- or 8-benzoyl-coumarin, since (*i*) it gave strong colouration with alcoholic ferric

chloride, and dissolved in alkali with non-fluorescent yellow colour and (*ii*) on Kostanecki acetylation with acetic anhydride and sodium acetate, coumarino-α- or -γ-pyrone was obtained (IV).
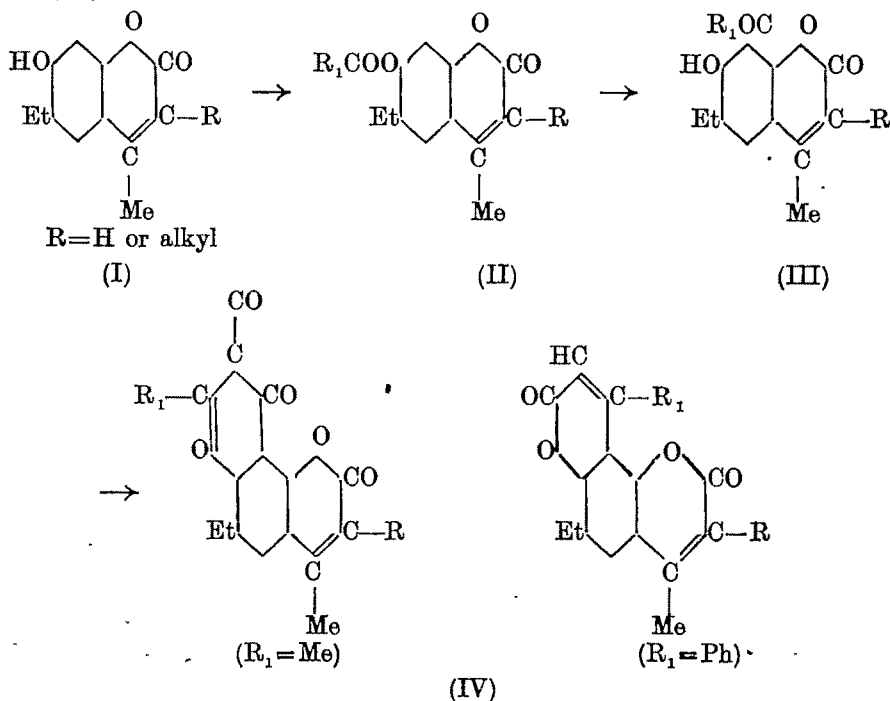
General Method of carrying out the Migration.—The acetyl or benzoyl derivative of 7-hydroxy-4-methyl-6-ethylcoumarin (II, R = H ; R_1 = Me or Ph) or of 7-hydroxy-4-methyl-6-ethyl-3- alkylcoumarin (II, R=CH$_3$, C$_2$H$_5$, C$_3$H$_7$, C$_4$H$_9$; R$_1$=Me or Ph) (1 mol.) was intimately mixed with aluminium chloride (3.3 mols.) and the mixture protected by CaCl$_2$ guard-tube was heated in an oil-bath at a particular temperature for a definite period. When the evolution of the hydrochloric acid gas slackened, the mixture was cooled, and ice and hydrochloric acid (10 c.c.) added and the solid that separated was collected and identified. The migration of 7-acetoxy-and 7-benzoyloxy-4-methyl-6-ethylcoumarin was investigated under different conditions and the results are tabulated below.

<div align="center">TABLE I</div>

(a) *Fries migration of 7-acetoxy-4-methyl-6-ethylcoumarin.*

Formation of 7-hydroxy-4-methyl-6-ethyl-8-acetyl-coumarin (III, R=H; R$_1$=Me).

Temp.	Unreacted ester	De-acetylated product	Migrated product	Remarks
115-120°	0.4 g.	0.9 g.	0.1 g.	Impure, m.p. 129-135°
130-140°	..	..	2.0	Pure, m.p. 140°
150-160°	..	..	1.0	Charred mass which on repeated crystallisations gave green crystals, m.p. 133-35°

All migrations were carried out with 2.45 g. of the coumarin ester.

(b) *Fries migration of 7-benzoyloxy-4-methyl-6-ethylcoumarin.*

Formation of 7-hydroxy-4-methyl-6-ethyl-8-benzoylcoumarin (III, R=H; R_1=Ph).

Temp.	Unreacted ester.	De-benzoylated product.	Migrated product.	Remarks.
120-130°	0.8 g.	0.6 g.	Indication	Gave $FeCl_3$ colour test but pure product could not be isolated.
135-140°	0.2	1.0	0.2 g.	m.p. 158-60°
150-160°	..	..	1.5	m.p. 160°
175-180°	..	..	0.7	Charred product which on repeated crystallisations gave crystals, m.p. 158-160°

All migrations were carried out with 2 g. of the coumarin ester.

The acetoxy or benzoyloxy derivatives of 7-hydroxy-4-methyl-6-ethyl-3-alkyl-coumarins were similarly studied and the results are tabulated below :

(1) The acetoxy derivatives were heated at 130-140° for one hour. (2) The benzoyloxy derivatives were heated at 155-160° for the same period. Otherwise the procedure was similar. (3) Unless otherwise stated, the solvent used for crystallisation is alcohol. (4) All the migration products dissolve in alkali giving a non-fluorescent yellow solution and give colour with ferric chloride in alcoholic solutions ; the acetyl compounds give cherry red, while the benzoyl compounds give violet colour.

TABLE II

No.	Original compound.	Migration product : Properties etc.	Acetyl derivative of the migration product.	Kostanecki acetylation of the migration product.
1	7-Acetoxy 3 : 4-dimethyl-6-ethylcoumarin	7-Hydroxy -3 : 4-dimethyl-6-ethyl-8-acetyl-coumarin, m.p. 125° (Desai & Mavani, *Proc. Ind. Acad. Sc.*, 1941, 14A, 100 give m.p. 121°)		3 : 4 : 2' -Trimethyl-6-ethyl-3' -acetyl-coumarino-(7 : 8 :5' : 6') -γ-pyrone, needles, m.p. 214.5° from benzene. (Found : C, 70.3 ; H, 5.8. $C_{18}H_{18}O_5$ requires C, 69.9 ; H, 5.5 per cent).
2	7-Acetoxy-3 : 6-diethyl-4-methylcoumarin	7-Hydroxy-3 : 6-diethyl-4-methyl-8-acetyl-coumarin, m.p. 149.5°. (Found : C, 69.8 ; H, 6.8. $C_{16}H_{18}O_4$ requires C, 70.0 ; H, 6.6 per cent).	Colourless needles, m.p. 109° (Found : C, 67.4 ; H, 6.4. $C_{18}H_{20}O_5$ requires C, 67.7 ; H, 6.3 per cent).	
3	7-Acetoxy-3-propyl-4-methyl-6-ethyl-coumarin	7-Hydroxy-3-propyl-4-methyl-6-ethyl -8-acetylcoumarin, m.p. 128°. Desai and Mavani give m.p. 129° (*loc. cit.*)	Colourless cubes, m.p. 128-9° (Found : C, 68.8 ; H, 6.9.$C_{19}H_{22}O_5$ requires C, 69.1 ; H, 6.7 per cent).	3-Propyl -4 : 2' -dimethyl-6-ethyl -3' -acetyl-coumarino-(7 : 8 : 5 : 6')-γ-pyrone, needles, m.p. 191-2° (Found : C, 71.0 ; H, 6.4. $C_{21}H_{22}O_5$ requires C, 71.2 ; H, 6.2 per cent).
4	7-Acetoxy-3-butyl-4-methyl-6-ethyl-coumarin	7-Hydroxy-3-butyl-4-methyl-6-ethyl -8-acetylcoumarin, Desai & Mavani (*loc. cit.*) give m.p. 124°	Colourless crystals, m.p. 120°. (Found : C, 69.5 ; H, 7.1. $C_{20}H_{24}O_5$ requires C, 69.8 ; H, 6.98 per cent).	3-Butyl-4 : 2'-dimethyl-6-ethyl-3'-acetyl-coumarino-(7 : 8: 5' : 6')-γ-pyrone, needles from acetic acid, m.p. 182° (Found : C, 71.5 ; H, 6.6. $C_{22}H_{24}O_5$ requires C, 71.7 ; H, 6.5 per cent).

TABLE II—(contd.)

No.	Original compound.	Migration product : Properties etc.	Acetyl derivative of the migration product.	Kostanecki acetylation of the migration product.
5	7-Acetoxy -4-methyl-6-ethylcoumarin	7-Hydroxy -4-methyl-6-ethyl-8-acetyl-coumarin, m.p. 140° (Desai & Ekhlas, *Proc. Ind. Acad. Sc.*, 1938, **8A**, 194 give m.p. 139° ; Limaye & Limaye give m.p. 135° *Rasayanam* 1941 ; 201)	Colourless needles, m.p. 131°. (Found : C, 66.5 ; H, 5.8. $C_{14}H_{16}O_5$ requires C, 66.7 ; H, 5.6 per cent).	4 : 2′ -Dimethyl-6-ethyl-3′ -acetylcoumarino-(7 : 8: 5′ : 6′)-γ-pyrone, needles, m.p. 192°
6	7-Benzoyloxy-4-methyl-6-ethylcoumarin	7-Hydroxy-4-methyl-6-ethyl-8-benzoyl-coumarin, m.p. 160°	Colourless needles, m.p. 154-55°. (Found: C, 71.6 ; H, 5.3. $C_{21}H_{18}O_5$ requires C, 72.0 ; H, 5.1 per cent).	4-Methyl-6-ethyl-4′-phenylcoumarino-(7 : 8 : 5′ : 6′)-α-pyrone, needles, m.p. 144° (Found : C, 75.4 ; H, 5.1. $C_{21}H_{16}O_4$ requires C, 75.9 ; H, 4.8 per cent).
7	7-Benzoyloxy-3 : 4-di-methyl-6-ethyl-coumarin	7-Hydroxy-3 : 4-di-methyl-6-ethyl-8-benzoylcoumarin, m.p. 138-39°. (Found : C, 74.4 ; H, 5.7. $C_{20}H_{18}O_4$ requires C, 74.5 ; H, 5.6 per cent).	Colourless needles, m.p. 168-9°. (Found : C, 72.2 ; H, 5.6. $C_{22}H_{20}O_5$ requires C, 72.5 ; H, 5.5 per cent).	3 : 4-Dimethyl-6-ethyl-4′-phenylcoumarino-(7 : 8 : 5′ : 6′)-α-pyrone, needles, m.p. 164-5° (Found : C, 76.1 ; H, 5.5. $C_{22}H_{18}O_4$ requires C, 76.3 ; H, 5.2 per cent).
8	7-Benzoyloxy-3 : 6-diethyl-4-methyl-coumarin	7-Hydroxy-3 : 6-diethyl-4-methyl-8-benzoylcoumarin, m.p. 139°. (Found: C, 74.8 ; H, 6.1.$C_{21}H_{20}O_4$ requires C, 75.0 ; H, 5.95 per cent).	Colourless needles, m.p. 131-2° (Found : C, 72.8 ; H, 6.0. $C_{23}H_{22}O_5$ requires C, 73.0, H, 5.8 per cent).	
9	7-Benzoyloxy-3-propyl-4-methyl-6-ethyl-coumarin	7-Hydroxy-3-propyl-4-methyl-6-ethyl-8-benzoylcoumarin, m.p. 134°. (Found : C, 75.3 ; H, 6.4. $C_{22}H_{22}O_4$ requires C, 75.4 ; H, 6.3 per cent).	Colourless needles, m.p. 141-2°. (Found : C, 73.2 ; H, 6.3. $C_{24}H_{24}O_5$ requires C, 73.5 ; H, 6.1 per cent).	3-Propyl-4-methyl-6-ethyl-4′-phenyl-coumarino-(7 : 8 : 5′ : 6′)-α-pyrone, needles, m.p. 194-5° (Found : C, 76.9 ; H, 6.0. $C_{24}H_{22}O_4$ requires C, 77.0 ; H, 5.9 per cent).
10	7-Benzoyloxy-3-butyl-6-ethyl-4-methyl-coumarin	7-Hydroxy -3-butyl-4-methyl-6-ethyl-8-benzoylcoumarin, m.p. 129° (Found : C, 75.6 ; H, 6.7. $C_{23}H_{24}O_4$ requires C, 75.8 ; H, 6.6 per cent).	Needles, m.p. 134-35°. (Found : C, 73.8 ; H, 6.5. $C_{25}H_{26}O_5$ requires C, 73.9 ; H, 6.4 per cent).	

The migration products 1 to 5 described here crystallise from acetic acid as yellow flaky needles ; while the rest crystallise from alcohol as needles.

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VITAMIN-C CONTENT OF SOME FRUITS AND VEGETABLES OF ASSAM

By R. K. Barua

The vitamin-C content of thirty-six samples of fruits and vegetables grown in Assam has been estimated. It is found that the vitamin-C content varies from province to province even for the same material, thus confirming earlier observations by other investigators.

A particular plant *Bryophyllum* shows increase in vitamin-C content when exposed to direct sunlight.

The determination of the vitamin-C content of Indian fruits and vegetables has been undertaken by various investigators (Ghosh and Guha, *J. Indian Chem. Soc.*, 1935, **12,** 34 ; Rothenheim, Mahmud and Cowlage, *ibid.*, 1938, **15,** 17 ; Sen-Gupta and Guha, *ibid.*, 1939, **16,** 549 ; Mitra and Roy, *ibid.*, 1940, **17,** 247). It has been found that vitamin-C content of the same material varies from place to place. Table I is illustrative of the variance of vitamin-C content of some of the substances grown in the different localities. Though in the other Indian provinces dietary surveys are carried out, yet no systematic investigation in this line has so far been undertaken in the province of Assam. An attempt therefore has been made to estimate the vitamin-C content of some common edibles (fruits and vegetables) of the province. The results of this investigation are shown in Table II.

In the present investigation with a particular plant *Bryophyllum* (Dupar-tenga), it is found that the amount of vitamin-C is greatest when exposed to direct sunlight. The same plant has been examined when it is covered with overhanging shrubs and then after the removal of the foliage. The results, shown in Table III, confirm the earlier observations of Giraud *et al.* (*Compt. rend. Soc. Biol.*, 1934, **117,** 612) and Murray and Stratton (*J. Nutrition*, 1944, **28,** 427) that vitamin-C content is greatest in plants exposed to full sunlight.

Experimental

The fruits and vegetables were samples found in and around the town of Gauhati and only fresh ones were taken, in many cases direct from the kitchen-gardens of the locality. In determining the vitamin-C content, the usual titrimetric method of Tillman as modified by Bessey and King (*J. Biol. Chem.*, 1933, **103,** 687) was followed. The samples (10 g.) were ground to a thin paste in a glass mortar with acid-washed white sand and 25 c.c. of a solution containing 8% trichloroacetic acid and 2% meta-phosphoric acid. The mixture was centrifuged and the clear liquid decanted. The mortar was rinsed and the centrifuging repeated with consecutive 10 and 5 c.c. portions of the extracting liquid, and the combined extracts made up to 50 c.c. An aliquot of the extract was diluted with distilled water (from glass) and titrated from a micro-burette with a standard solution of 2 : 6-dichlorophenol-indophenol, to a permanent faint pink end-point. A blank titration of an equivalent amount of extracting solution was also done. The analysis of each sample was completed in the same day following the recommendations of Mapson and Mawson (*Nature,* 1943, **151,** 222).

TABLE I

Vitamin-C content of fruits and vegetables of different places

English name.	Scientific name.	Vitamin-C content in mg. per 100 g. of the substance			
		Assam	Bengal (Guha *et al.*)	Bihar (Mitra & Roy)	Other determinations
Bean	*Dolichos lab lab*	6.6	7	17.4—17.8	5—12.5*
Bottle gourd (leaves)	*Lageneria vulgaris*	8.5	5	33	..
Cabbage	*Brassica oleracea capitata*	27	14—20.8	..	25—75*
Chillies	*Capsicum indicum*	5.5	4 (Bombay) 45 (Malda) 10 (Patna)	..	10—20*
Indian plum	*Zizyphus jujuba*	12	..	22.3—30.5	..
Lemon	*Citrus medica*	17+	36.1+		
Onion (green stalks)	*Allium sepa*	6	..	22.7	
Orange	*Citrus auranticum*	36+	18—30.6+	..	
Pumpkin (leaves)	*Cucurbita maxima*	9.2	11	38.7	
Ridge gourd	*Luffa acutangulata*	16	..	15.8	
Shaddock	*Citrus decumana*	7	26	..	
Spinach	*Spinach oleracea*	6.4	6—14.9	41	
Tomato	*Lycopersicum esculentum*	13	27.3	..	
Wood-apple	*Aegle marmelos*	7.5	18—86.7	4.7	

TABLE II

Vernacular name.	English name.	Scientific name.	Values of vitamin-C content per 100 g. of substance
Bandha Kabi	Cabbage	*Brassica capitata*	27
Bilahibengena	Tomato	*Lycopersicum esculentum*	13
Urahi	Bean	*Dolichos lab-lab*	6.6
Jhilmil sak (leaves)	..	*Chinapodium album*	5
Sajina pat	Leaves of Horse radish	*Moringa oleifera*	22.5
Sajina phul	Flowers of Horse radish	,,	10
Lafa sak	Leaves of common mallow	*Malva verticillata*	4
Chuka sak	Leaves of Rumex	*Rumex vesicarius*	4
Babari sak	A kind of Basil	..	8
Mula sak	Leaves of Radish	*Raphanus sativus*	5.6
Lai sak		*Brassica Rugosa*	4
Olkabi		*Brassica oleracea*	10.6
Dhania sak	Leaves of Coriander	*Coriandum sativum*	5.3
Lao-Ag	Tender leaves of white gourd	*Lageneria vulgaris*	8.5
Rangalao-Ag	Do of Pumpkin	*Cucarbita maxima*	9.2
Rangalao-phul	Flowers of pumpkin	,,	11
Farash	French-bean	*Phaseolus vulgaris*	8.8
Matar pat	Leaves of pea	*Piscum arvensa*	7.3
Tengeshitenga	Oxalis	*Oxalis cornuculata*	4.5
Saf pat	Leaves of Anise	*Pimpinella anisum*	8.7

* These values are taken from Tables compiled by Hawk (Practical Physiological Chemistry, 11th edition).

† Per 100 c.c. of the pulp.

TABLE II (contd.)

Vernacular name.	English name.	Scientific name.	Values of vitamin-C content per 100 g. of substance
Dupar-tenga	Leaves of Bryophyllum	*Bryophyllum*	11.7
Paleng	Spinach	*Spinach oleracea*	6.4
Piyaz pat	Leaves of onion	*Alium sepa*	6
Jika	Ridge-gourd	*Luffa acutangulata*	16
Amlakhi	Emblic myrobalan	*Phyllanthus amblica*	7.2
Outenga	..	*Dillenia indica*	10.8 (unripe Sept. 3.2 (ripe Dec.)
Kardai (ripe)	Carambola	*Averrhoa carambola*	2.3
Jalphai	Olive	*Elaeocarpus serratus*	4
Sumtheratenga	Orange	*Citrus auranticum*	43 per 100 c.c. (Oct.) 36 ,, (Jan.)
Nemutenga (ripe)	Lemon	*Citrus medica*	17 per 100 c.c.
Bel (ripe)	Wood-apple	*Aegle marmelos*	7.5
Amara (ripe)	Hog plum	*Spondius mangijera*	4.3
Bagari	Indian plum	*Zizyphus jujuba*	12
Rabab Tenga (ripe)	Shaddock	*Citrus decumana*	7
Amita (unripe)	Papaya	*Carica Papaya*	14
Jalakia	Green chillies	*Capsicum indicus*	5.5

TABLE III

Date of estimation.	Condition of the plant. (*Bryophyllum*)	Vitamin-C content in mg. per 100 g. of leaves.
21.10.45	Covered with overhangings	4.3
3.1.46	After removal of overhangings on 22.10.45	11.7

DISCUSSION

From Tables I and II, it is seen that vitamin-C content of the same substances grown in the three different Indian provinces (Bengal, Bihar and Assam) varies. The vitamin-C content of substances growing in Bihar records a maximum with least values for Assam. An exception is seen in the cases of orange juice and cabbage. This may be explained by the fact that the oranges and cabbages were fresh from the gardens in this determination while in a city like Calcutta they might not have been available in such a fresh condition. It is found that with maturity the vitamin-C content gradually decreases in the case of *Dillemia Indica* thus confirming the view of Ghosh and Guha (*loc. cit.*). It may possibly be due to this reason that we notice rather too low values for carambola, lemon, shaddock and hog plum, which were very ripe at the time of investigation.

My thanks are due to Prof. I. B. Sarkar for the facilities he has given me to carry on this piece of work.

ACRIDINES AS ANTISEPTICS. PART II

By P. Das-Gupta and P. Gupta

Various sulphonamides have been reacted with 5-aminoacridine to form 'onium' salts and their bacteriostatic properties have been compared with 5-aminoacridine and the respective sulphonamide.

Recently sulphonamide compounds are being used as local antiseptics but it is generally noticed that minute amounts of p-aminobenzoic acid antagonise the antibacterial effects of sulphanilamide derivatives containing a free 'p-amino' grouping. Of course, compounds are now known which are not affected by the presence of p-amino grouping in the sulphanilamide molecule (*cf.* Goetchius and Lawrence, *J. Bact.*, 1945, **49**, 575). An idea is gaining ground that the above antagonism is due to the interference with some metabolic function of bacterial cell. Mudd (*J. Bact.*, 1945, **49**, 527) further suggests that sulphanilamide has affinity for respiratory enzyme protein and as such compounds like sulphapyridine, sulphathiazole, sulphadiazine, containing groups as present in co-enzyme complex, exert a more enhanced antibacterial activity. On this hypothesis, incorporation of any other component known to inhibit the respiratory enzymes of the bacterial cells might increase the antibacterial effect of a sulphanilamide derivative. Recently, Haas (*J. Biol. Chem.*, 1944, **155**, 315, 321) has noticed the inhibitory action of ' atebrin ' on the respiratory enzyme. ' Atebrin ' is a 5-aminoacridine derivative and the 5-aminoacridines have again been noticed to exert pronounced bactericidal action (Rubbo, Albert and Maxwell, *Brit. J. Expt. Path.*, 1942, **28**, 69 ; *cf.* Das-Gupta and Gupta, *J. Indian Chem. Soc.*, 1945, **22**, 364). Accordingly it was considered to be of interest to study the influence of this 5-aminoacridine on some simpler and well known sulphanilamides like p-aminobenzene sulphonamide, sulphanilacetamide, sulphanilylbenzamide, sulphapyridine and sulphathiazole. As the latter compounds are somewhat acidic in nature, it was expected that they would react readily with 5-aminoacridine and the resulting compounds might be easily compared with the parent sulphanilamides as well as with mixtures containing molar amounts of the different components.

The different salts of the general formula (III) obtained by the interaction of the sulphanilamides' of the form (I) with 5-aminoacridine (II) are not equally stable. The sulphabenzamide, the sulphacetamide and sulphathiazole compounds, obtained by reacting in a hydrated solvent (alcohol), can be easily crystallised out from the same solvent. The interaction between sulphapyridine and 5-aminoacridine may be better carried out in a non-hydrated solvent, but the 'onium' compounds easily break up into the constituent parts. This is quite in keeping with the acidic properties of the different sulpha compounds as is evident from their acid dissociation constants as found in this laboratory.
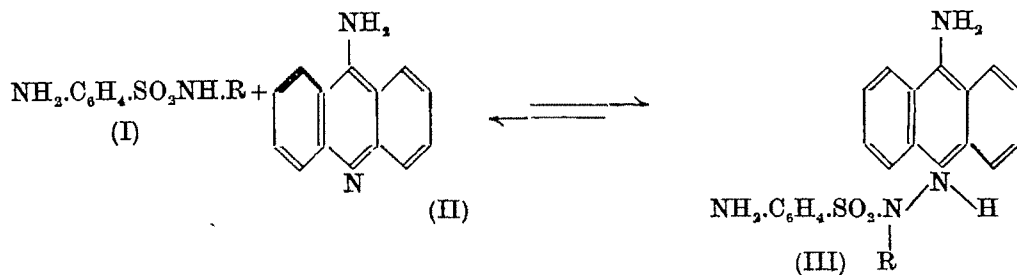
The various onium compounds, equimolecular mixtures of 5-aminoacridine and the different sulphanilamides, 5-aminoacridine itself and the individual sulphanilamide derivative were incubated at 37° for 72 hours in a medium made from papain digest-glucose-phosphate meat broth containing about 500 organisms per 5 c.c. of broth. The table below shows the minimal inhibiting concentration expressed in milligrams of the antiseptic (drug) per 100 c.c. of broth. From the table it would be noticed that the antibacterial activity of the sulphanilamide derivatives (column under *a*) is considerably enhanced by incorporation of 5-aminoacridine whether in the form of their onium salt (column *c*) or in the form of equimolecular mixture (column *b*). In inhibiting the growth of *strepto haemolyticus* as well as that of *staph.aureus*, the two common pathogenic organisms met with in common wounds and abrasions, a synergistic action is noticed whenever a sulpha drug is mixed with 5-aminoacridine. As these antiseptics might be useful in the treatment of various types of wounds and abrasions, work is in progress to prepare certain ointments in suitable water-washable bases incorporating these compounds for study of their antibacterial activities by the well known cup agar plate method.

TABLE I

Antibacterial activity in vitro

Minimal inhibiting concentration in mg. of drug per 100 c.c. of culture medium at 37.5° for 72 hours.

Organism	5-Aminoacridine	Sulphathiazole			Sulphanilyl benzamide			Sulphanilyl acetamide			Sulphapyridine			Sulphanilamide	
		a	b	c	a	b	c	a	b	c	a	b	c	a	b
Bact. Coli	2	1	1	1	5	5	5	10	5	2	1	5	5	100	2
Strep. haemolyt	1	15	0.5	0.2	..	1	0·5	1	0.5	..	1	0.5	..	..	0.5
Staph. Aureus	2	>10	1	1	>20	5	4	>50	4	2	10	4	4	>50	1
Bact. Proteus	2	2	2	2	..	4	10	..	4	4	..	4	4	..	4
B. pyocyanea	10	50	20	50	..	20	50	..	20	50	..	50	50	..	50
Bact. Dysent Flexner (y)	..	0.4	1	0.5	10	2	2	20	1	1	2	2	2	..	1
V. Choleras (Inaba)	..	..	0.4	0.2	..	0.5	0.5	..	2	2	1	0.5	0.5	..	0.2
Pnemo, Type I	..	0.1	1	1	..	2	1	..	2	1	..	1	1	..	1
Enterococcus	..	..	1	0.2	..	4	2	..	2	1	..	4	2	..	..
B. Typhosus	..	>5	1	1	>100	2	2	>50	2	2	5	2	2	>100	1

a—Sulphanilamide derivative alone

b—Mixture of the sulphanilamide derivative and 5-aminoacridine.

c—Compound formed by the sulphanilamide derivative with 5-aminoacridine.

EXPERIMENTAL

5-Aminoacridonium sulphathiazole.—To a solution of 5-aminoacridine (1 g.) in 95% spirit, was added sulphathiazole (1.3 g.) and the mixture refluxed till complete solution. On cooling, shining yellow crystals of 5-aminoacridonium sulphathiazole, m.p. 218° (decomp.), were obtained. (Found : N, 14.99. $C_{22}H_{19}O_2N_5S_2$ requires N, 15.59 per cent).

5-Aminoacridonium sulphacetamide.—Similarly 5-aminoacridine (1 g.) dissolved in 95% spirit was refluxed with *p*-aminobenzene sulphacetamide (1.1 g.) for about 10 minutes when shining yellow crystals of 5-aminoacridonium sulphacetamide were obtained. Solids collected after cooling were purified by recrystallisation from spirit, m.p. 258° (decomp.). (Found : N, 13.86. $C_{21}H_{20}O_3N_4S$ requires N, 13.72 per cent).

5-Aminoacridonium sulphabenzamide.—To a clear solution of 5-aminoacridine (1 g.) in alcohol was added a clear solution of *p*-aminobenzene sulphabenzamide (1.4 g.) in alcohol and shaken thoroughly well. After about half an hour, shining yellow crystals of 5-aminoacridonium sulphabenzamide began to appear. These were filtered and washed well with alcohol when crystals, m.p. 226°, were obtained. (Found : N, 11.6. $C_{26}H_{22}O_3N_4S$ requires N, 11.9 per cent).

5-Aminoacridonium sulphapyridine.—To a solution of 5-aminoacridine (1 g.) in acetone was added a solution of 2-sulphanilylpyridine (1.2 g.) in acetone. The acetone solution was concentrated at room temperature in partial *vacuo*, then diluted with water when shining light yellow needle-shaped crystals, m.p. 131°, were obtained. (Found : N, 13.9 ; H_2O, 11.3. $C_{24}H_{21}O_2N_5S$, $3H_2O$ requires N, 14.08 ; H_2O, 10.8 per cent).

5-Aminoacridonium sulphanilamide.—To 5-aminoacridine (1 g.) dissolved in rectified spirit was added *p*-aminobenzene sulphonamide (0.88 g.) dissolved in spirit and shaken thoroughly. After standing overnight, 5-aminoacridonium sulphanilamide, m.p. 222° (decomp.), was obtained on diluting with ether as shining yellow crystals. (Found : N, 10.93 ; H_2O, 25.5. $C_{19}H_{18}O_2N_4S$, $7H_2O$ requires requires N, 11.3 ; H_2O, 25.6 per cent).

Our thanks are due to Mr. P. Sen-Gupta, M.Sc., for supplying us with the data showing the bacteriostatic activity of the different compounds and our best thanks are due to Dr. U. P. Basu for his interst in the work.

A SIMPLE RELATION BETWEEN VISCOSITY AND SURFACE TENSION OF LIQUIDS*

BY A. S. CHACRAVARTI

Newton Friend's equation $(\gamma = k\sqrt{\eta})$ has been shown to apply very well to the viscosity and surface tension data on a number of unassociated liquids belonging to different families. The constant, *k*, agrees with the quantity (Parachor/Rheochor) within fairly close limits as expected.

In contrast to the various complicated equations connecting viscosity and surface tension of liquids (Silverman and Roseveare, *J. Amer. Chem. Soc.*, 1932, **54**, 4460 ; Buehler, *J. Phys. Chem.*, 1938, **42**, 1207 ; Tripathi, *J. Indian Chem. Soc.*, 1942, **19**, 51) Newton Friend's equation (*Nature*, 1942, **150**, 432 ; *Phil Mag.*, 1943, **34**, 643) : $\gamma = k\sqrt{\eta}$ between viscosity and surface tension of unassociated liquids is one of remarkable simplicity. It contains no arbitrary constant as *k* is given by the quantity $(P/R)^1$; *P* (parachor) can be calculated from atomic and structural constants, the same possibility being indicated for *R* (rheochor) as well (Bhagwat, Toshniwal and Moghe, *J. Indian Chem. Soc.*, 1944, **21**, 29). In the present paper, the relation has been shown to apply very well to a number of unassociated liquids over wide ranges of temperature (Table I). Except for a few erratic cases, invariably at the lowest or highest temperatures, the equation fits in with data on most substances within 2 to 3%.

* This work was done in the Chemical Laboratory, Science College, Patna.

<div align="center">TABLE I</div>

Liquid.	Temp. range.	k.	Order of % diff. between obs. & calc. values.
Octane	0—100°	285	4
Ethyl iodide	0—70°	365	2
Ethyl formate	0—50°	367.5	2
Ethyl acetate	0—70°	340	2
Chloroform	0—60°	355	1
Chlorobenzene	20—160°	390	4
Propyl acetate	0—100°	310	3
Methyl ethyl ketone	0—80°	360	2
*iso*Butyl bromide	0—90°	315	2
Dioxan	20—90°	340	3
p-Xylene	10—130°	380	3
m-Xylene	0—130°	365	4
Acetone	—73 to 56°	400	3
Benzene	0—100°	360	4

In Table II, k is compared with $(P/R)^4$ in several cases. The rheochor data of Bhagwat *et al* (*loc. cit.*), where available, were used, parachors being calculated from atomic and structural constants. Considering that the rheochor data used are based on determinations at only one temperature, the agreement is satisfactory.

<div align="center">TABLE II</div>

Liquid.	k.	$(P/R)^4$.	Order of % diff.
Ethyl formate	367.5	342	6
Ethyl acetate	340	342	0
Chloroform	355	378	6
Methyl ethyl ketone	360	378	5
Acetone	400	399	0
Benzene	360	368	2
m-Xylene	365	377	3
Octane	285	297	4

Table III shows typical instances (a good and a bad fit) of agreement between observed values of γ and those calculated with the equation, $\gamma=(P/R)^4 \sqrt{\eta}$. It will be seen that for ethyl acetate (good fit), the agreement is within 1% in most cases, while for octane (bad fit), values agree within a little over 4% excepting at the two highest temperatures where errors in measurement are most apt to occur. The usefulness of the equation in that it leads to the surface tension from viscosity at the same temperature (over wide ranges) or *vice versa* merely from a knowledge of atomic and linkage values of parachor and rheochor is thus apparent.

<div align="center">TABLE III</div>

Temp.	$\eta \times 10^4$.	γ obs.	γ calc.	% Diff.
	(a) Octane : $P=346.2$. $R=83.38$.	$(P/R)^4=297$.		
0°	70.60	23.85	24.96	—4.4
10	61.59	22.80	23.31	—2.2
20	54.19	21.75	21.86	—0.4
30	48.28	20.7	20.64	0.3
40	43.28	19.6	19.10	2.5
50	39.07	18.6	18.56	0.2
60	35.51	17.6	17.70	—0.6
70	32.41	16.5	16 91	—2.4
80	29.71	15.5	16.21	—4.8
90	27.30	14.4	15.52	—7.2
100	25.20	13.38	14.91	—11.4

<div align="center">TABLE III (contd.)</div>

Temp.	$\eta \times 10^4$.	γ obs.	γ calc.	% Diff.
	(b Ethyl acetate :	$P = 216.0$.	$R = 50.21$. $(P/R)^4 = 342$	
0°	58.25	25.50	26.10	—2.4
10	51.20	24.35	24.47	—0.5
20	45.46	23.24	23.06	0.7
30	40.72	21.81	21.82	—0.0
40	36.69	20.78	20.72	—0.3
50	33.34	19.60	19.75	—0.8
60	30.45	18.61	18.87	—1.5
70	27.80	17.70	18.05	—2.1

CENTRAL RESEARCH STATION,
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OXIDATION OF ARTOSTENONE WITH HYDROGEN PEROXIDE IN PRESENCE OF OSMIC ACID IN EXCESS

BY M. C. NATH, SUDHIR RANJAN CHOWDHURY AND MOTAHER UDDIN

A monoketo-monocarboxylic acid of artostenone has been prepared both from artostenone and dihydroxyartostanone. Its oxime, anilide and semicarbazone have been described.

It has previously been reported from this laboratory (Nath, *Z. physiol. Chem.*, 1937, 249, 71) that artostenone (I), the steroid ketone occurring in *Artocarpus integrifolia*, when oxidised with potassium permanganate in both neutral and acid medium, gives rise to the diketo-artostanic acid ($C_{30}H_{50}O_4$) (Nath, *Z. physiol. Chem.*, 1937, 247, 9). This also confirmed the hypothesis laid down by Windaus (*Ber.*, 1906, 39, 2008) towards the possible chemical changes in such process. Nath and Chakravorty (*J. Indian Chem. Soc.*, 1944, 22, 19) have shown recently that artostenone forms an addition compound with hydrogen peroxide in presence of osmic acid, thus forming a dihydroxy compound (II).

It was observed that some amorphous powder was also obtained during this process, the yield of which varied with the proportion of osmic acid used. When osmic acid was added in trace, the yield of this amorphous powder was very low and the dihydroxy compound was obtained in abundance; while addition of the catalyst in excess gave rise to a greater yield of this amorphous powder. Hence, it was thought that the excess of osmic acid might have some effect in bringing about further chemical changes in the dihydroxy compound formed and giving rise to a new compound (III).

In order to verify this, the reactions were conducted with an excess of osmic acid on artostenone and also on the dihydroxy compound when osmic acid was added in trace. In both the reactions, the same amorphous powder was obtained which could ultimately be crystallised.

$$\text{(I)} \xrightarrow[\text{Osmic acid}]{H_2O_2} \text{(II)}$$

(I)   (II)

$$\text{(I)} \xrightarrow[\text{Osmic acid (excess)}]{H_2O_2} \text{(III)} \xleftarrow[\text{(Osmic acid)}]{H_2O_2} \text{(II)}$$

(III)
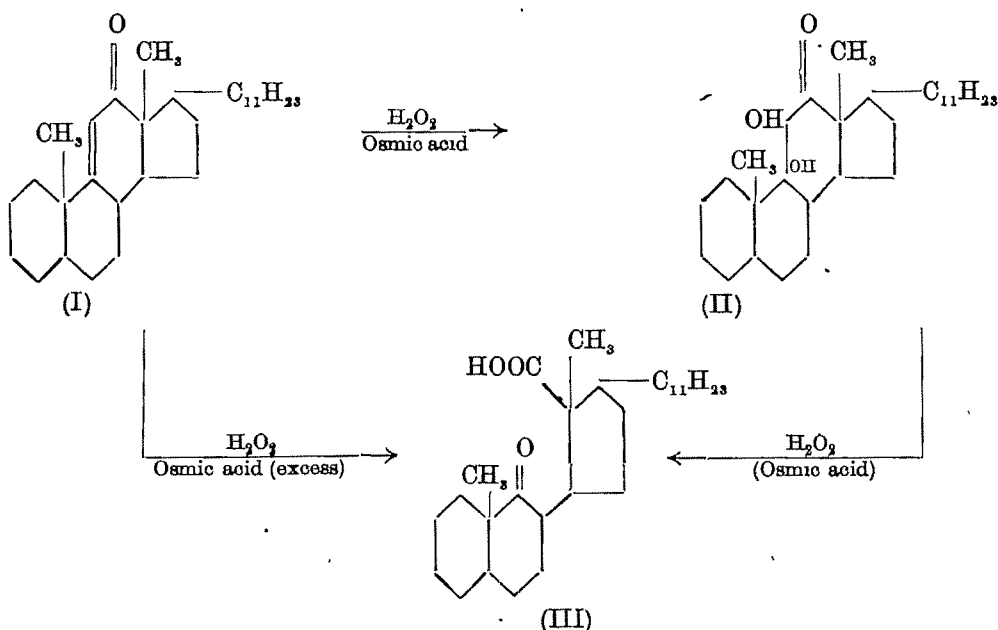
<center>E X P E R I M E N T A L</center>

Artostenone (1 g.) was dissolved in ether (100 c.c.) and treated with osmic acid (0.1 g.) in 10 c.c. of ether. Perhydrol (30 c.c.) was then added to the mixture, which was allowed to remain for 20 hours at ordinary temperature. The resulting solution was then allowed to evaporate completely and dried without application of heat, until the odour of osmic acid was removed. It was once again dissolved in ether and the solution was decolourised with one or two drops of perhydrol and evaporated. The colourless and semicrystalline residue after several crystallisations from 80% alcohol and then from methyl alcohol gave crystals melting at 88°. [Found : C, 77.93 ; H, 11.05 ; M.W. (cryoscopic in benzene), 442.6. $C_{29}H_{50}O_3$ requires C, 78.02 ; H, 11.21 per cent. M.W., 446].

<center>*Preparation of derivatives.*</center>

(a) *Oxime.*—The substance (0.1 g.) was dissolved in 1 c.c. of alcohol and hydroxyl-amine hydrochloride (0.5 g.) and an excess of sodium acetate added. The mixture was then refluxed for 15 minutes, cooled, diluted with water and shaken with ether in a separating funnel. The solution on removal of ether left a solid residue, which was crystallised from absolute alcohol as needles, m.p. 165°. (Found : N, 3.2. $C_{29}H_{51}O_3N$ requires N, 3.03 per cent).

(b) The *anilide* was prepared by refluxing for about 1 hour the substance (0.2 g.) with 2 c.c. of aniline and the mixture was then poured into ice but no precipitate was obtained. The whole thing was then heated on a water-bath, and most of the free aniline evaporated off. A sticky mass, thus obtained, was dissolved in methyl alcohol, the solution was warmed with norit, filtered and a few drops of water were added. On keeping for a few days, some stout transparent crystals separated out, which melt at 112°. (Found : N, 2.59. $C_{35}H_{57}O_3N$ requires N, 2.59 per cent).

(c) *Semicarbazone.*—The substance (0.1 g.) was dissolved in alcohol (1 c.c.), and an aqueous alcoholic solution of semicarbazide hydrochloride (0.1 g.) and an excess of sodium acetate were added. The solution was refluxed for 6 hours on a water-bath, cooled and poured into water. A precipitate was obtained, which was filtered, washed repeatedly with water and finally crystallised from alcohol, m.p. 115-16°. (Found : N, 8.30. $C_{30}H_{53}O_3N_3$ requires N, 8.35 per cent).

DISCUSSION

It has previously been mentioned that artostenone on treatment with hydrogen peroxide in presence of osmic acid gives rise to dihydroxyartostanone (m.p. 141-42°). When the amount of osmic acid is increased in the reaction a keto-acid melting at 88° has been obtained in abundance. This keto-acid has also been prepared by reacting dihydroxyartostanone with hydrogen peroxide in presence of osmic acid. This indicated that the dihydroxy compound is the intermediate product towards the formation of the keto-acid. This may also be noted that though cholestenone can be converted into the monoketo-carboxylic acid of cholestenone by oxidation with potassium permanganate (Windaus *loc. cit.*), artostenone failed to give the monoketo-acid by the same method of procedure. It has been possible, however, to obtain this desired compound through an entirely different intermediary product, the dihydroxyartostanone, by means of hydrogen peroxide in presence of osmic acid. Percentage of nitrogen as estimated from oxime and semicarbazone indicated the presence of one keto group in the keto-acid.

PHYSICO-CHEMICAL STUDIES OF COMPLEX FORMATION BETWEEN MOLYBDIC AND TARTARIC ACIDS. PART II. STUDIES ON THE OPTICAL ROTATION PROPERTIES OF MOLYBDOTARTARIC ACID COMPLEX IN PRESENCE OF DIFFERENT BASES, ACIDS AND ALCOHOLS

By Anil Bhusan Biswas

The stability of complex molybdotartaric acid in different p_H and in solutions contain-ing suitable organic acids, alcohols and phenols which are expected to form similar co-ordina-tion complex as tartaric acid, has been examined by measuring optical rotatory power. The change of the rotation values of such complex solution has been associated mainly with the preferential formation of the undissociated acid or its ions between p_H limits 1.0 and 4 2 and the complex breaks beyond that on either side. The relative affinities of oxalic, malonic, succinic, citric and malic acids for complex formation with molybdic acid in solution con-taining tartaric acid are calculated from optical rotation values.

In Part I of the series (*J. Indian Chem. Soc.*, 1945, 22, 351) the cause of enhanced rotation exhibited by a solution of *d*-tartaric acid in presence of molybdic acid, has been ascribed to the formation of a co-ordination complex compound,
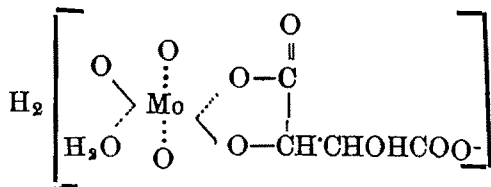
The normal molybdate ion (MoO_4'') is known to be unstable in acidic medium and so it readily co-ordinates with other similar ions to form polymolybdates or with the tartrate ion. when present in the solution, to form molybdotartrate complex. But the molybdate ion is stable in neutral or alkaline solutions and hence in these systems, the complex compound formation cannot be expected.

If to a solution containing molybdotartrate complex another inactive organic acid, whose anion also is capable of forming a co-ordination complex with molyb-date ion, is added, a new equilibrium condition will be attained ; the concentration of the two complex compounds from the two organic acids will depend on their relative affinities for molybdate ion, and thus it may be possible to compare, from changes in optical rotation values, the relative affinities of different co-ordinating substances.

Another factor which affects the stability of complex in cases where the groups occupy two co-ordination points, as indicated in the present case, is the length of the closed chain. Five-membered ring is more easily formed than higher ones as can be tested by adding substances which can form closed chain compounds of higher order.

In the present investigation, we have studied (1) the stability of molybdo-tartrate complex at different p_H adjusted by adding strong and weak bases and

also by strong and weak acids which have little tendency for complex formation ; (2) the relative affinity of tartaric acid for complex formation with molybdic acid in presence of similar organic hydroxy-acids or phenols and alcohols which also can form similar complexes ; and (3) the relative tendency of molybdic acid to form five or more membered closed chain compounds.

EXPERIMENTAL

The influence of the following substances on the optical rotation values of molybdotartaric acid complex in solution has been observed, the rotations having been measured similarly as described in Part I using a 0'54 dm. tube at 25°.

(a) Bases	Caustic soda and ammonia
(b) Acids	HCl, H_2SO_4, CH_3COOH and mono-, di-, and tri-chloroacetic acids
(c) Dibasic carboxylic acids	Oxalic, malonic and succinic acids
(d) Hydroxy-acids	Citric and malic acids
(e) Phenols and alcohols	Catechol, salicylic acid and glycerol.

Action of Bases like NaOH and NH_4OH.

The neutralisation of a solution containing $0.0252M$-molybdic acid (calculated as MoO_3) and $0.0252M$-H_2T (tartaric acid) with $0.838N$-NaOH (representative of a strong base) and $0.873N$-NH_4OH (representative of a weak base) has been followed to see whether the nature of the base has any influence on the rotation values or in rotation-neutralisation curves at any stage. The results are presented in Tables IA and IB.

TABLE IA

$\dfrac{NaOH}{H_2T}$	Observed rotations at wave-lengths			
	690μμ.	578μμ.	546μμ.	436μμ.
0.00	+0.44	+0.53	+0.62	+1.16
0.53	+0.52	+0'65	+0'76	+1.43
1.59	+0.71	+0'80	+1.01	+2.05
2.12	+0.62	+0.76	+0.87	+1.74
3.44	+0 14	+0.20	+0.22	+0.37
4.24	+0.07	+0.11	+0.13	+0.24

TABLE IB

$\dfrac{NH_4OH}{H_2T}$	Observed rotations at wave-lengths			
	690μμ.	578μμ.	546μμ.	436μμ.
0.55	+0.53	+0.67	+0.74	+1.44
1.65	+0.70	+0.91	+1.02	+2.06
2.31	+0.60	+0.77	+0.88	+1.75
3.59	+0.11	+0.14	+0.16	+0.30
4.42	+0'05	+0.08	+0.10	+0.18

The behaviour of pure tartaric acid solution during similar neutralisation with NaOH has also been examined and the results are represented in Table II.

TABLE II

Titration of $0.0988M$-H_2T solution with $N/2$-NaOH.

$\dfrac{NaOH}{H_2T}$	Observed rotations at wave-lengths			
	690μμ.	578μμ.	546μμ.	436μμ.
0 00	+0.12	+0.13	+0.15	+0.20
0.84	+0.18	+0.19	+0.22	+0 32
1.69	+0.23	+0'26	+0.32	+0.50
2.10	+0.25	+0.32	+0.35	+0.55
2.94	+0.28	+0.32	+0.36	+0.55

The Action of HCl, H_2SO_4, *Acetic acid and its three Chloro-acids.*

These acids are of widely different strengths and their relative influences on a complex acid solution are noted in Tables IIIA and IIIB below.

TABLE III A

Influence of H_2SO_4 *and* HCl *on a solution containing* $0.0252M\text{-}MoO_3$ $+0.0252$ $M\text{-}H_2T$.

Conc. of the acid.	pH.	Observed rotations at wave-lengths			
		$690\mu\mu$.	$578\mu\mu$	$546\mu\mu$.	436 $\mu\mu$.
		H_2SO_4			
0.00M	1.99	+0.44	+0.54	+0.62	+1.18
0.03	1.31	+0.34	+0.44	+0.52	+0.98
0.06	0.86	+0.26	+0.36	+0.42	+0.76
0.09	0.80	+0.23	+0.26	+0.32	+0.62
0.15	0.63	+0.20	+0.23	+0.27	+0.53
		HCl			
0.00M	1.99	+0.44	+0.54	+0.62	+1.20
0.01	1.70	+0.38	+0.50	+0.58	+1.14
0.04	1.27	+0.34	+0.48	+0.56	+0.96
0.09	0.84	+0.26	+0.34	+0.42	+0.80
0.19	0.65	+0.21	+0.25	+0.29	+0.59

TABLE III B

Influence of acetic acid and its three chloro-acids on the optical rotation of a solution containing $0.0241M\text{-}MoO_3 + 0.0241M\text{-}H_2T$.

Conc. of acid.	pH.	Observed rotations at wave-lengths			
		690 $\mu\mu$.	578 $\mu\mu$.	546 $\mu\mu$	436 $\mu\mu$.
		Acetic acid. $K = 1.8 \times 10^{-5}$			
0.00M	2.02	+0.41	+0.50	+0.60	+1.11
0.12	1.98	+0.40	+0.48	+0.59	+1.10
0.97	1.91	+0.38	+0.46	+0.56	+1.05
2.15	1.85	+0.35	+0.42	+0.51	+0.98
		Monochloroacetic acid $K = 1.6 \times 10^{-3}$.			
0.00	2.02	+0.41	+0.50	+0.60	+1.11
0.19	1.78	+0.37	+0.44	+0.54	+1.03
0.25	1.62	+0.35	+0.42	+0.50	+1.00
0.82	1.40	+0.34	+0.40	+0.49	+0.95
		Dichloroacetic acid. $K = 5 \times 10^{-2}$.			
0.00	2.02	+0.41	+0.50	+0.60	+1.15
0.10	1.37	+0.34	+0.41	+0.47	+0.95
0.18	*1.23	+0.30	+0.36	+0.41	+0.83
0.32	*1.17	+0.30	+0.35	+0.42	+0.82
0.88	*1.10	+0.30	+0.35	+0.41	+0.81
		Trichloroacetic acid. $K = 3 \times 10^{-1}$.			
0.00	2.02	+0.41	+0.50	+0.60	+1.15
0.08	1.35	+0.32	+0.40	+0.45	+0.89
0.14	*1.21	+0.30	+0.37	+0.41	+0.82
0.21	*1.01	+0.29	+0.36	+0.41	+0.81
0.27	0.86	+0.26	+0.30	+0.35	+0.69
0.30	0.70	+0.21	+0.27	+0.32	+0.61

Influence of Oxalic, Malonic and Succinic Acids.

The complex formation between molybdic and oxalic acids has been reported by Rosenheim (*Z. anorg. Chem.*, 1896, **11**, 225) and Spittle and Wardlaw (*J. Chem. Soc.*, 1931, 1748). The results on the addition of the above acids in increasing amounts to a solution containing $0.0261M$-$MoO_3 + 0.0261M$-H_2T, are shown in Table IV.

TABLE IV

Rotations at wave lengths

Conc. of acid.	pH.	690 μμ.		578 μμ.		546 μμ.		486 μμ.	
		Obs.	Corrected for pH	Obs.	Corrected, for pH	Obs.	Corrected for pH	Obs.	Corrected for pH
					Oxalic acid.				
0.00M	1.94	+0.48	—	+0.59	—	+0.66	—	+1.30	—
0.0070	1.92	+0.39	+0.39	+0.50	+0.50	+0.57	+0.57	+1.10	+1.11
0.0188	1.87	+0.30	+0.31	+0.39	+0.40	+0.45	+0.46	+0.90	+0.93
0.0268	1.80	+0.20	+0.22	+0.23	+0.25	+0.29	+0.32	+0.54	+0.59
0.0393	1.70	+0.12	+0.15	+0.15	+0.19	+0.10	—	+0.34	+0.42
					Malonic acid.				
0.00	1.94	+0.48	—	+0.59	—	+0.66	—	+1.30	—
0.0085	1.92	+0.47	—	+0.58	—	+0.65	—	+1.28	—
0.0247	1.88	+0.46	—	+0.55	—	+0.62	—	+1.25	—
0.0616	1.86	+0.41	+0.42	+0.50	+0.51	+0.57	+0.59	+1.13	+1.16
					Succinic acid.				
0:00	1.94	+0.48	—	+0.59	—	+0.66	—	+1.30	—
0.0094	1.92	+0.46	—	+0.58	—	+0.65	—	+1.27	—
0.0182	1.91	+0.45	—	+0.56	—	+0.63	—	+1.25	—
0.0700	1.89	+0.43	0.44	+0.55	+0.56	+0.62	+0.63	+1.21	+1.22

In the above tables the optical rotation values under the head "obs" are observed rotations after the addition of the respective acids, and under the head "corrected for pH" are the rotation values after correction for the partial diminution of rotation caused by increase of [H⁺]. This aspect is dealt with later on.

Influence of Organic Hydroxy-acids like Malic and Citric Acids.

Due to their similarity in structure with tartaric acid, they are expected to form complexes readily with molybdic acid. Darmois and collaborators (*Compt. rend.*, 1925, **180**, 921 ; 1924, **179**, 629 ; 1924, **178**, 2183) and Travers and Malaprade (*Bull. Soc. chim.*, 1926, **39**, 1408) observed complex formation between molybdic and malic acids. In the present case we have used inactive malic acid so that the resulting complex becomes optically inactive, The influence of the two acids in increasing amounts on a solution containing $0.0219M$-$MoO_3 + 0.0219M$-H_2T has been studied as represented in Table V.

TABLE V

Rotations at wave-lengths

Conc. of acid.	pH.	690 μμ		578 μμ		546 μμ		436 μμ	
		Obs.	Corrected for pH	Obs.	Corrected for pH	Obs.	Corrected for pH	Obs.	Corrected for pH
				Malic acid.					
0.00M	2.09	+0.37	—	+0.46	—	+0.52	—	+1.06	—
0.0112	2.00	+0.31	+0.32	+0.40	+0.42	+0.45	+0.47	+0.86	+0.92
0.0280	1.92	+0.26	+0.28	+0.36	+0.39	+0.41	+0.45	+0.75	+0.82
0.0561	1.88	+0.23	+0.27	+0.28	+0.33	+0.32	+0.38	+0.60	+0.71
0.0841	1.76	+0.21	+0.25	+0.24	+0.30	+0.28	+0.35	+0.54	+0 67
				Citric acid.					
0.00	2.09	+0.37	—	+0.46	—	+0.52	—	+1.06	—
0.0055	1.89	+0.32	+0.33	+0.39	+0.41	+0.44	+0.45	+0.90	+0.94
0.0111	1.76	+0.24	+0.28	+0.27	+0.33	+0.31	+0.36	+0.59	+0.72
0.0330	1.72	+0.18	+0.20	+0.19	+0.26	+0.23	+0.31	+0.43	+0.58
0.0550	1.70	—		+0.17	—	+0.20	—	+0.39	—

Influence of Catechol, Salicylic acid and Glycerol.

The above are often known to form compounds similar to tartaric acid as exhibited by enhanced conductivity and [H⁺] (Holleman, "Organic Chemistry", 1925, p.275). The affinities are compared with that of tartaric acid in a solution containing $0.0219M$-MoO_3 and $0.0219M$-H_2T and the results are noted in Table VI.

TABLE VI

Observed rotations at wave-lengths.

Conc.	pH.	690μμ.	578μμ.	546μμ.	436μμ.
		Catechol.			
0.00M	2.09	+0.37	+0.46	+0.52	+1.06
0.08	2.07	+0.36	+0.46	+0.51	+1.03
0.15	2.04	+0.35	+0.44	+0.50	+1.02
		Salicylic acid.			
0.00	2.09	+0.37	+0.46	+0.52	+1.06
0.08	2.07	+0.36	+0.44	+0.51	+1.05
0.20	2.00	+0.34	+0.41	+0.47	+0.98
		Glycerol.			
0.00	2.09	+0.37	+0.46	+0.52	+1.06
0.15	2.07	+0.37	+0.46	+0.52	+1.04
0.30	2.06	+0.35	+0 45	+0.50	+1.02

DISCUSSION

The Action of NaOH and NH₄OH.

The action of the two bases are more or less similar in affecting the rotation values of the complex acid solution. The rotation values first increases during neutralisation and passes through a maximum followed by rapid decrease until it reaches a steady value which is the same as that given by pure H_2T solution

under similar conditions. From the p_H—rotation curves (not shown) it appears that the maxima at all concentrations of the complex acids, are always near p_H 4.2 and the minima of steady rotations are reached at p_H 7.0.

Britton and Jackson (*J. Chem. Soc.*, 1934, 1035) interpreted the region, where rotation values increase, to be due to the increasing formation of the complex, the maximum complex formation occurred near p_H 4.0, when tartaric acid was 3/4 neutralised. There is no justification for such assumptions. We have advanced here a more reasonable interpretation to co-ordinate all the observed facts better looking into the parallel behaviour of the active component, viz, H_2T under similar conditions. We have seen in Table III similar to the observations of Vle's and Vellinger (*Compt. rend.*, 1925, 180, 742) and Britton and Jackson (*J. Chem. Soc.*, 1934, 978) that the rotation value of a tartaric acid solution gradually increases during neutralisation with NaOH and ultimately a steady value is attained. This phenomenon is associated with the different molecular rotatory powers of H_2T (non-ionised tartaric acid), HT' (acid tartrate ion) and T'' (tartrate ion) which are of increasingly higher order ; a steady value is reached when tartaric acid is completely dissociated containing T'' ion in solution responsible for the observed steady value. Similar phenomenon operates during the neutralisation of the complex acid solutions.

The non-ionised complex acid $H_2[MoO_3T, H_2O]$ and its two ions $H[MoO_3T, H_2O]'$ and $[MoO_3T, H_2O]''$ have rotatory powers of increasingly higher order and hence the rotation values increased during neutralisation due to the formation of the stronger rotatory complex ions more and more by progressive ionisations. But beyond p_H 4.2, $[MoO_3T, H_2O]''$ ion is unstable and begins to dissociate into its components ; the rotation values rapidly fall due to large difference between rotatory powers of the complex ion and T'' ion. This dissociation becomes complete near p_H 7.0, when rotations observed are due to T'' ion only. This is in accordance with our expectations indicated before, that MoO_4'' is stable in neutral or alkaline medium and hence in such systems it will freely ionise in the solution unco-ordinated with tartrate or similar organic anions.

If we assume that the complex anion of the molybdotartaric acid does not decompose at or before p_H 4.2 and the complex acid remains completely ionised at this p_H, then in a system free of uncombined H_2T the observed maximum rotation value at this p_H may be ascribed to the complex ion $[MoO_3T, H_2O]''$ only and hence the molecular rotation of this ion can be determined thus : the rotation values observed under the stated conditions are

$$\alpha_{690\mu\mu}^{25°} = +0.30 \; ; \quad \alpha_{578\mu\mu}^{25°} = +0.38 \; ; \quad \alpha_{546\mu\mu}^{25°} = +0.43 \; ; \quad \alpha_{436\mu\mu}^{25°} = +0.91$$

for a concentration of $1.061 \times 10^{-2} M$ of $[MoO_3T, H_2O]''$. Therefore the molecular rotation values at respective wave-lengths are 28.28, 35.82, 40.53 and 85.76 for 0.54 dm. length at 25°.

The Action of HCl, H_2SO_4, Acetic acid, etc.

While the increase of rotation values of a complex solution with the addition of alkali is caused by the formation of stronger rotatory ions of the complex acid,

conversely the decrease of pH in such systems should diminish the rotation values by the repression of ionisation when less rotatory molecules or ions will be formed. When strong acids like H_2SO_4, HCl are added to a solution containing the complex acid and its ions, the rotation values decrease continuously. Provided the complex does not break at low pH, it is expected that there will be a definite pH value (depending on the ionisation constant of the complex acid) below which the acid will remain completely unionised, the rotation value will then remain steady. But this steady region could not be revealed with H_2SO_4 or HCl, probably the complex acid is unstable in their presence at low pH value.

The influence of acids like acetic acid and its three chloro-acids, whose strengths are of gradually increasing order ($K = 1.8 \times 10^{-5}$ to 3×10^{-1}), on the complex solution has been studied alternatively. Acetic acid and monochloroacetic acid are probably weak to suppress completely the ionisation of the complex acid. But the desired region is revealed in the case of di- and trichloroacetic acids where the rotation values remained constant even when the pH dropped from 1.20 to 1.00. But with trichloroacetic acid the rotation values diminished below pH 1.0. If we assume again that the complex acid in solution remains completely unionised between pH 1.2 and 1.0, the molecular rotation of unionised acid can be determined from rotation values observed under the stated conditions thus :

$$\alpha^{25^\circ}_{690\mu\mu} = +0.30 ; \quad \alpha^{25^\circ}_{578\mu\mu} = +0.38, \quad \alpha^{25^\circ}_{546\mu\mu} = +0.41, \quad \alpha^{25^\circ}_{436\mu\mu} = 0.82$$

are the observed rotation values when the concentration of the complex acid is $1.987 \times 10^{-2}M$. The molecular rotation values at respective wave-lengths are 15.09, 18.11, 20.63 and 41.25 for a 0.54 dm. tube at 25°.

The Action of Oxalic acid, etc.

While oxalic acid causes rapid decrease in rotation values (Table IV) with increasing concentration, the other two acids, viz. malonic and succinic acids, have little influence in affecting the rotation of a molybdotartaric acid solution ; probably in the latter cases, if they are to form a co-ordination complex, the length of the closed chain increases from 5 members in the case of tartaric and oxalic acids, to 6 and 7 respectively for malonic and succinic acids as shown below and thereby the affinity for combination is weakened.

Oxalic acid complex   Malonic acid complex   Succinic acid complex
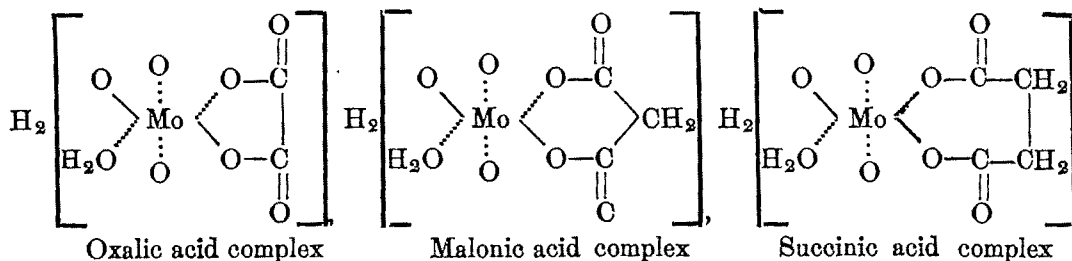
The presence of oxalic acid in a solution of molybdotartaric acid complex (MoT) creates in the system a new equilibrium of the type.

$$H_2\left[MoO_3T, H_2O\right] + (COOH)_2 \underset{\longleftarrow}{\overset{K}{\longrightarrow}} H_2\left[MoO_3(OOC)_2, H_2O\right] + H_2T$$
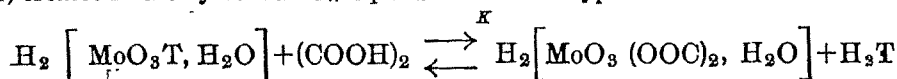
If the applicability of Mass Law in such a complex system is assumed, the value of the equilibrium constant (K) will be given by

$$K = \frac{[\text{Oxalato complex}] \times [\text{H}_2\text{T}]}{[\text{Tartrate complex}] \times [(\text{COOH})_2]} = \frac{[\text{MoOx}]\,[\text{H}_2\text{T}]}{[\text{MoT}]\,[\text{Ox}]}$$

The oxalato complex is optically inactive and so the observed rotations at any stage in presence of oxalic acid are due to (MoT) and uncombined H_2T. The diminution of rotation is due to the proportional transformation of MoT to MoOx. It is now possible to determine the value of K from the data in Table IV. A typical calculation is shown below.

In the starting solution the concentration of molybdotartaric acid, i.e. [MoT], as calculated from the equations given in Part I, is $0.0215M$ and $[\text{H}_2\text{T}]$ is equal to $(0.0261-0.0215)$. If x be the amount (in molarity) of MoT decomposed by the addition of $0.007M$ oxalic acid (Ox), then x will also be equal to the concentration of the new oxalato complex, i.e., [MoOx] and an equivalent amount of H_2T will be liberated in the solution. Then

$$K = \frac{x \times [\text{H}_2\text{T} + x]}{[\text{MoT} - x]\,[\text{Ox} - x]}.$$

Now the observed rotation $=$ (original concentration of $\text{MoT} - x) \times$ molecular rotation of $\text{MoT} +$ (original conc. of $\text{H}_2\text{T} + x) \times$ molecular rotation of H_2T.

The molecular rotations of MoT and H_2T for a 0.54 dm. polarimeter tube at the 4 wave-lengths in question are taken from the values given in Part I.
Then $0.39 = (0.0215 - x) \times 22.4 + (0.0046 + x) \times 1.01$ (for wave-length 690 $\mu\mu$)

$$x = 0.0048$$

and $K = \dfrac{[\text{MoOx}] \cdot [\text{H}_2\text{T}]}{[\text{MoT}][\text{Ox}]} = \dfrac{(0.0048) \times (0.0046 + 0.0048)}{(0.0215 - 0.0048)\,(0.0070 - 0.0048)} = 1.23$

similarly the values of K are calculated from other data and represented in Table VII.

It will be noticed that along with the diminution in rotation values by the addition of oxalic acid, the pH of the system also decreases and obviously this is also partly responsible for the diminution of optical rotation. With reference to Table IIIB for dichloroacetic acid, the proportional decrease of rotation for a certain pH drop is known ; thus the observed rotation values in Tables IV and V are corrected for the rotation that the solution in question would give if there were no change from the original pH caused by the addition of foreign substances. These corrected values are noted in respective tables and only those are used for determining K. Similarly the following equilibrium constants K_1, K_2 K_3 and K_4 are also determined from recorded data in Tables IV and V

$$K_1 = \frac{[\text{MoO}_3 \cdot \text{Malonic}]\,[\text{H}_2\text{T}]_{\text{free}}}{[\text{MoT}]\,[\text{Malonic acid}]_{\text{free}}} \cdot \quad K_2 = \frac{[\text{MoO}_3 \cdot \text{Succinic}]\,[\text{H}_2\text{T}]_{\text{free}}}{[\text{MoT}]\,[\text{Succinic acid}]_{\text{free}}}$$

$$K_3 = \frac{[\text{MoO}_3 \cdot \text{Malic}]\,[\text{H}_2\text{T}]}{[\text{MoT}]\,[\text{Malic acid}]_{\text{free}}} \quad ; \quad K_4 = \frac{[\text{MoO}_3 \cdot \text{Citric}]\,[\text{H}_2\text{T}]}{[\text{MoT}]\,\text{Citric acid}]_{\text{free}}}$$

TABLE VII

Acid	Oxalic	Citric	Malic	Malonic	Succinic
Mean of relative equilibrium constants 13×10^2	153	86	16 5	2.67	1.17

From the above table an idea about the comparative affinities, relative to tartaric acid, of different acids for complex formation with molybdic acid is obtained. While oxalic acid has more affinity than tartaric acid, citric acid has got slightly less and malic acid has still less affinity. The affinities of the other two acids, viz., malonic and succinic acids are much smaller.

Referring to Table VI, phenols, phenolic acid and alcohols appear to have negligible affinities for complex formation in presence of tartaric acid.

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PHYSICO-CHEMICAL STUDIES OF COMPLEX FORMATION BETWEEN MOLYBDIC AND TARTARIC ACIDS. PART III. ULTRAMICROSCOPIC STUDIES ON THE CHANGE OF PARTICLE NUMBER AND CATAPHORETIC VELOCITY OF MOLYBDIC ACID SOL PARTICLES DURING COMPLEX FORMATION

BY ANIL BHUSAN BISWAS

That an appreciable portion of molybdic acid in its sol is present as true solution and also the presence of tartaric acid in the sol transforms the colloidal particles into solution, have been shown by counting the number of particles per c.c. with an ultramicroscope. The cataphoretic velocity of molybdic acid sol particles, either alone or in presence of tartaric acid at different pH has been studied and the results discussed.

The work of Dumanskii and collaborators (*J. Russ. Phys. Chem. Soc.*, 1928, **60**, 1053 ; *Kolloid Z.*, 1929, 48, 49) indicated the existence of a "colloidal complex" when tartaric acid (H_2T) was added to a sodium tungstate solution. This can be advantageously tested if we start with a colloidal solution and follow with a ultramicroscope the change of particle number taking place with the addition of an organic acid.

We started with a molybdic acid sol in which an appreciable percentage of the acid was present as true solution and the sol particles were found to be negatively charged. Dhar and collaborator (*J. Indian Chem. Soc.*, 1943, **20**, 282) assumed the likely existence of an equilibrium of the type

$$n\mathrm{HA} \rightleftharpoons \left(\mathrm{HA}\right)_n \rightleftharpoons \left[(\mathrm{HA})_m \cdot x(n\mathrm{A})y\,\text{Å}\right]$$

Simple molecules,   Polymerised molecules.   Colloidal particles negatively charged.

2
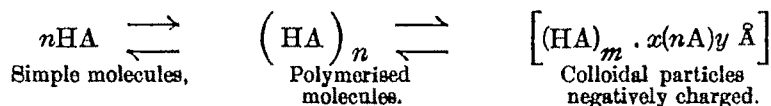
The negative charge on the particle is chiefly due to the adsorption of x-polymerised anions carrying n units of electric charge and y of simple anions, each carrying one unit of charge. The existence of such an equilibrium is capable of being verified experimentally by ultramicroscopic studies. When a carefully dialysed sol of molybdic acid is observed in a slit ultramicroscope, the number of visible particles per c.c. is generally small (about 10^9 per c.c. in $0·02M$-MoO_3 sol). The molybdic acid mostly exists as invisible micelles or probably even in simple molecular state. If, however, a coagulating electrolyte is added, the number of visible particles increases to about 10^{12} per c.c.

In this type of colloidal acids, bases or ampholytes, the surface charge density σ is determined by surface ionisation and so small changes of H^+ activity of the solution may result in an appreciable variation in the value of σ. Mukherjee and collaborators (*Trans. Nat. Inst. Sci., India*, 1935, I, 47) in a review, have shown that the electrokinetic behaviours of colloidal particles depend mainly on the surface charge density and hence measurement of cataphoretic velocity (C. V.) of molybdic acid sol particles during complex formation with tartaric acid under different conditions, may furnish useful information regarding changes taking place on the surface of the sol particles.

The object of the present investigation is to afford a direct evidence by ultramicroscopic examination, firstly of the existence of an appreciable portion of molybdic acid in its sol in true solution and secondly, of the formation of molybdotartrate complex in the true solution at the expense of colloidal particles. The change of cataphoretic velocity of sol particles in presence of tartaric acid at different concentrations and p_H has been measured in order to throw light on the changes taking place on the surface of particles under stated conditions.

EXPERIMENTAL

Particle Counting.—The number of particles per c.c. in different sols was counted with the help of a slit ultramicroscope. The cell containing the colloidal solution was illuminated with a strong light beam of known thickness using an eye-piece reticule and with a proper stop (slit of known dimensions) only a definite volume of the solution could be made visible through the eye-piece. The sol in question, was diluted properly with optically void water so that particles varying from 2 to 6 in number could come at a time within the field of vision. Such numbers were then counted after definite time intervals, the signal for which was given by the tick from a metronome. The mean of at least 200 such readings was taken in each case and the particle number per c.c. was then calculated. The results are shown in Table I.

TABLE I

No. of particles observed in pure MoO_3 sol (0.02 M) 0.83×10^9 per c.c.

      Do   after addition of electrolyte (HCl) 1.24×10^{12} per c.c.

Conc. of H_2T (in mols)	0.0	0.49×10^{-2}	0.98×10^{-2}	1.92×10^{-1}	3.92×10^{-2}	5.76×10^{-2}
Ratio $\dfrac{H_2T}{MoO_3}$	0.0	0.25	0.5	1.0	2.0	3.0
No. of particles per c.c.	0.83×10^9	0.18×10^9	0.28×10^8	0.9×10^7	0.86×10^6	Nil

As with the addition of electrolyte for coagulation of MoO_3 in the sol, the particle number per. c.c. is enormously increased, the additional particles must have come from MoO_3 present in the true solution. The addition of H_2T in increasing amounts gradually diminishes the number of particles in the resulting mixtures and when the ratio $H_2T : MoO_3 = 3$, i. e, the mols. of H_2T is 3 times the mols. of molybdic acid in a mixture, no particle is apparently visible in the system. The sol particles are then completely transformed into true solution either as a complex with H_2T or as simple molecules.

It should be noted here that the above figures of particle numbers are not strictly quantitative, but give an approximate idea of the phenomena occurring under the stated conditions.

Cataphoretic Velocity Measurements.—The cataphoretic velocity of particles in different systems is measured in a Mattson's cylindrical cell, the experimental details and arrangements of which are the same as described by Ghosh and collaborator (*J. Indian Chem. Soc.*, 1942, **17**, 721). The pH of the systems under different conditions was adjusted by adding requisite quantity of NaOH and the measurements of C. V. were made one hour after each addition of electrolytes. The results are tabulated below.   C. V. is expressed in cm./sec./volt/cm.

TABLE II

Change of cataphoretic velocity of molybdic acid sol particles with pH.

(a)   Conc. of MoO_3 in the pure sol $= 0.029M$

pH	2.48	2.88	3.60	3.97	4.20	4.64
C.V. $\times 10^5$ ...	-25.6	-25.9	-29.8	-35.6	-37.5	-37.9

TABLE III

Variation of cataphoretic velocity of molybdic acid sol particles in presence of tartaric acid and also with change of pH.

(b) Composition of the sol $= 0.0165$ M-$MoO_3 +$ 0.0094 M-H_2T		(c) Composition of the sol $= 0.0165$ M-$MoO_3 +$ 0.0164 M-H_2T		(d) Composition of the sol $= 0.0165$ M-$MoO_3 +$ 0.0318 M-H_2T	
pH.	C.V.	pH.	C.V.	pH.	C.V.
2 36	-24.4×10^{-5}	2.19	-18.1×10^{-5}	2.01	-15.6×10^{-5}
2.69	$-28 2$	2.85	-20.2	2.67	-16.9
3.49	-33.4	3.42	-28.2	3 74	-28.7
4.03	-33.1	4.28	-24.2	4.18	-26.1
4.40	-28.0	4.52	-25.7	4.78	-25.0
5.01	-36.6	5.43	-36.4	5.24	-35.0 .

It appears from Table II that in the case of pure MoO_3 sol particles, the increase of p_H causes the gradual increase of C. V. But in Table III it will be noticed that the presence of increasing amount of H_2T in the sol diminishes the value of C. V. It increases in the beginning, followed by a decrease over a small range near about p_H 4.0. As the p_H is further increased, C. V. increases until the particles disappear from view, the system becoming optically void.

DISCUSSION.

According to Mukherjee (*Trans. Faraday Soc.*, 1921, **16**, 103) and Mukherjee and collaborators (*loc. cit.*), the double layer round the particles in colloidal solutions is regarded as made up of three parts, viz., the primarily adsorbed layer, the electrically adsorbed layer and the mobile sheet. The surface charge density σ, is given by the net excess of charge of the sign, being the sum of the charges carried by ions present per unit area in the form of primarily and electrically adsorbed ions and this σ is the main factor which determines C. V., and the change of C. V. can be suitably explained according to this hypothesis in preference to that of Guoy and Stern.

The micelles of molybdic acid are negatively charged The concentration of MoO_3 in the sol is found to influence the value of C. V. It decreases with the increase of concentration of MoO_3 in the sol and this can be readily understood when it is found that the p_H value of the system decreases simultaneously. This causes increased electrical adsorption of hydrogen ions when σ decreases and consequently the value of C. V. diminishes. The presence of increasing amount of H_2T in a MoO_3 sol diminishes the C. V. of particles due probably to the decrease of p_H.

When OH' ions are continuously added to the sol, the density of negative charge on the sol particles continuously increases due to the desorption of electrically adsorbed H ions and thus the C. V. increases.

But in presence of H_2T the behaviour is found to be different. This peculiar change of C. V. can be reconciled if we picture it as adsorption of H_2T by valency forces, the increased ionisation of the adsorbed H_2T with the addition of OH', when C. V. increases in the beginning, then desorption of adsorbed tartrate ions due to the weakness of the valency bond beyond p_H 4.0 ; when C.V. is found to decrease the ultimate increase of C. V. may be due to similar reasons as in the case of pure MoO_3 sol. This problem will be dealt with more fully later on.

My best thanks are due to Sir J. C. Ghosh for his kind interest in this work.

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PHOTO-REACTION BETWEEN IODINE AND SALTS OF CARBOXYLIC ACIDS IN PRESENCE OF METAL IONS AS CATALYSTS

By P. S. MacMahon and T. N. Srivastava

Photo-reaction between aqueous solutions of salts of hydroxy-carboxylic acids and iodine at appreciable rates takes place only in the presence of traces of certain metallic salts. An essential feature of these reactions is the formation of complex anions containing the metal. The kinetics, measured by the rate of disappearance of free iodine in the system, is the net result of a series of complicated simultaneous reactions, an outline of which is given.

The results indicate the existence in aqueous solution of a number of co-ordination complex salts of metals with hydroxy-carboxylic acids under conditions which require further investigation.

The experimental work, the results of which are summarised in this paper, was undertaken in an attempt to find out whether the salts of any of the other simple carboxylic acids react with I_2 in a manner capable of kinetic measurement, like the well known $K_2C_2O_4 - I_2$ photo-reaction. Inspite of some claims to the contrary (Mukherjee and Dhar, *J. Phys. Chem.*, 1928, **32**, 1308 ; 1929, **33**, 850) it soon became evident that when the reagents were carefully purified there was no appreciable reaction between I_2 (in the presence of KI) and the sodium salts of the following carboxylic acids at temperatures upto 40° :

Acetic, propionic, butyric, succinic, maleic, benzoic, phthalic, glycollic, malic, tartaric, citric, mandelic and glyceric.

On the other hand, we have found that addition of traces of the following salts immediately promotes reaction with hydroxy-carboxylic acids in light :

Manganese, chromium, iron, cobalt, uranyl salts and cerium ; nickel being a notable exception. Carboxylic acids containing no OH groups do not react with I_2 in light in the presence of added catalysts, with the exception of $Mn^{\cdot\cdot}$, which is oxidised to insoluble H_2MnO_3.

It has been observed that at temperatures betwwen 30° and 40° all these re-actions proceed with negligibly slow velocity both in the light (using a 1000 watt lamp as source) and in the dark if the reactants used are pure and precautions are taken to prevent loss of I_2 by evaporation.

The most effective photo-catalysts were found to be $Mn^{\cdot\cdot}$ and $Cr^{\cdot\cdot\cdot}$. The concentration of catalysts employed varied from 0.091 milliatom of the metal ion to 3.64 milliatom per litre (*i. e.* about 1 to 40 milliatoms of the catalysts in the presence of 50 mM of I_2 and 1000 mM of Na-salt) and at these concentrations the reactions are rapidly accelerated in light, the effect being roughly proportional to the concentra-tion of catalyst. In the dark, the reactions are extremely slow. In the presence of $Fe^{\cdot\cdot\cdot}$, $(UO_2^{\cdot\cdot})$, $Co^{\cdot\cdot}$ and $Ce^{\cdot\cdot\cdot}$ the reaction rates were considerably slower in the light of a 1000 watt lamp, but still very rapid in sunlight. The curves for the relative rates of reaction were all of the same type, so only one set is reproduced by way of illustration, that of sodium malate and iodine.

Although some attempts have appeared in the literature, it does not seem possible to draw any useful conclusions concerning the kinetics of the reactions

FIG. 1

Time in min.
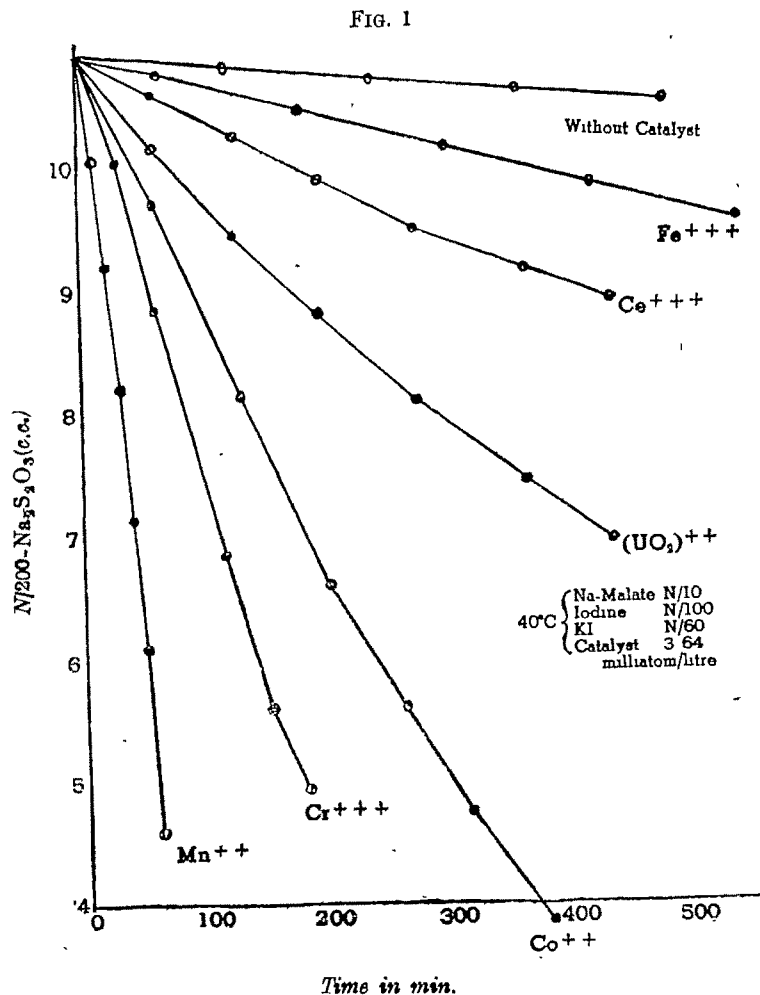
from a study of these curves. The factors which influence the reaction rates are many ; thus increase of $[H^+]$ ultimately suppresses it, whereas withdrawal of I_2 in the equilibrium :

$$I' + I_2 \underset{\rightarrow}{\leftarrow} I_3^{\varepsilon'},$$
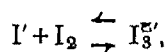
as the amount of I′ present progressively increases in the course of the reaction, renders kinetic interpretation impossible. Moreover, it has been found that in some systems solid iodination products appear, which effectively rules out photochemical measurement for the purposes of determining the order of reaction, quantum yield etc. Other complications will be referred to later. The curves obtained show the relative effectiveness of the added metal ions in promoting reaction, the nature of which can be further studied by examining the reaction products. A summary of the results so far obtained is shown in Table I.

TABLE I

Sodium salts.	Catalytic activity of the metal ions (3.64 milliatoms per litre).	Products of photo-reaction with I_2 using the catalysts mentioned.	Products of photo-reaction with $FeCl_3$.	Products of reaction with manganic alum.	Products of reaction with chromic acid.
Citrate	Mn>Cr>Ce>(UO₂)>Co>Fe	(Mn, Cr, Ce, Fe) tetra & hexa-iodoacetones and acetone.	Acetone dicarboxylic acid and acetone.	Acetone dicarboxylic acid and acetone.	Acetone.
Tartrate	Mn>Cr>Co>Fe>(UO₂)	(Mn, Cr, Co, Fe) glyoxalcarbonic acid and glyoxal.	Glyoxalcarbonic acid & very small quantities of glyoxal.	Glyoxalcarbonic acid & very small quantities of glyoxal (in light). In dark these products have not been detected.	...
Malate	Mn>Cr>Co>(UO₂)>Ce>Fe	(Mn, Cr, Co, Fe) small quantities of iodoform.	Acetaldehyde & a product giving hydrazone with 2:4-dinitrophenylhydrazine (not yet identified).	A product giving hydrazone with 2:4-dinitrophenylhydrazine (not yet indentified).	...
Mandelate	Cr>Mn>Fe>(UO₂)>Ce	(Mn, Fe) benzaldehyde; (Cr) benzaldehyde & phenyl glyoxalic acid.	Benzaldehyde.	Benzaldehyde.	Benzaldehyde & phenyl-glyoxalic acid.
Lactate	Cr>Mn>Fe>Co>(UO₂)>Ce	(Mn) acetaldehyde; (Cr) pyruvic acid & small quantities of iodoform; (Fe) small quantities of iodoform.	Acetaldehyde.	Acetaldehyde.	Acetic acid.
Glycollate	Mn >Cr >Co >Fe	(Mn. Cr) formaldehyde.	...	Formaldehyde.	Formaldehyde.
Glycerate	Cr >Mn >Fe >Co	(Mn, Cr) glyoxal.	...	Glyoxal.	...

The relative order of effectiveness of the various metal catalysts is unaffected by changes of concentration of reactants, changes in temperature, changes in p_H, or nature of the cation. The end-products, which were identified by the usual methods, are in all cases simple oxidation products or iodination compounds derived from these. There is a general similarity between the results obtained with different catalysts, with a few exceptions, indicating a similar reaction-mechanism irrespective of the catalyst employed.

The end solutions, after the free I_2 had been used up photochemically, were usually found to contain the metal in a higher state of valency than that originally employed. They were with few exceptions photochemically sensitive, disappearing with a measurable velocity, rapidly in light, slowly in the dark. Identification of a higher valency state in the case of manganese for example was shown as follows :—

The end solutions, no longer containing free I_2, are brown in colour, dialysable (absence of colloidal complexes) and become colourless when further exposed to light (reduction to Mn'' condition).

- The brown solutions (i) give the pink colouration of potassium manganioxalate when treated with $K_2C_2O_4$, (ii) start the "Eder" reaction with $K_2C_2O_4$ and $HgCl_2$ under N_2 in the dark, (iii) liberate I_2 from KI ; all indicating the presence of tervalent Mn in a comparatively stable form, i.e., as a complex, since simple Mn''' salts decompose immediately in aqueous solution and are also instantly reduced by I'.

Iron Complexes.—Among the acids mentioned above, formation of iron complexes was found to be restricted only to those containing OH groups. The best known of these are the tartrates, the formation of two types of which, identified by Franke (*Annalen*, 1931, **486**, 242) may be written

$$\text{(I)} \quad \left[C_4H_4O_6 \right]^{--} + Fe^{+++} \rightleftarrows \left[C_4H_2O_6Fe \right]^- + 2H^+$$

$$\text{(II)} \quad 3\left[C_2O_2H_4(COO)_2 \right]^{--} + Fe^{+++} + 3OH^- \rightleftarrows \left[C_6O_6H_9Fe(CO_2)_6 \right]^{6-} + 3H_2O$$
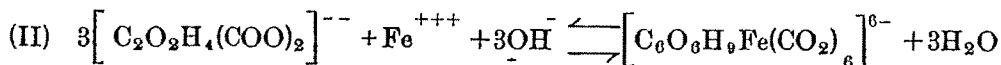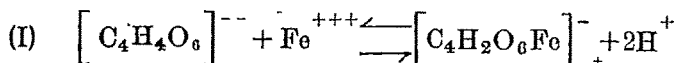
containing 4-co-ordinate and 6-co-ordinate tervalent Fe respectively. The presence of an acid group like OH is necessary to take up one of the co-ordinate positions in the anion. As already stated, only hydroxy-carboxylic acids have been found to react with I_2 in the presence of metal catalysts ; the formation of complex anions is thus an essential link in these reactions.

The effect of light on systems containing (I) and (II) (which are stable in the dark) may be summarised as follows :

The deep citron-yellow solution of sodium tartrate and ferric chloride in equimolecular proportions (I), containing free ferri-tartaric acid, is highly photosensitive. The acid decomposes rapidly in sunlight leaving a solution containing the whole of the iron in the ferrous state, together with glyoxalcarbonic acid and small amounts of glyoxal. Neutralisation of the H by addition of NaOH pro-

portionately reduces the light sensitivity. In the presence of 3 mol s. of NaOH (II) a reddish brown solution is obtained which is completely stable both in the light and in the dark.

All other hydroxycarboxylates tabulated above gave the same citron-yellow solutions in the anionic complex form with Fe^{+++}, decomposable photochemically, giving the products shown in column 4 of Table I.

The effect of increasing the concentration of H^+ is to decompose these complexes. In systems such as those employed in our original experiments with I_2, the initial buffer action of large excess of sodium tartrate nullifies the effect of the H^+, so that we have at first conditions favourable for the production of the equilibrium in (II). The oxidation products in column 3 are practically identical with those shown in column 4. It may be noted that Benrath (*Annalen*, 1911, **382**, 222 ; *J. prakt. Chem.*, 1917, **204**, 190) obtained similar products by the action of ferric salts on the free acids in sunlight. Ciamician and Silber (*Ber.*, 1913, **46**, 1558 ; 1914, **47**, 640) also obtained almost the same results (explained as being due to autoxidation) by exposing these acids for prolonged periods to sunlight in sealed bulbs containing air or oxygen. It seems highly probable that Ciamician and Silber's results (*loc. cit.*) were not due to autoxidation, but to the presence in solution of traces of iron, which are removable only with great difficulty.

It appears from the above that the photo-reaction is not due to self-reduction of the complex ion, as stated by Franke, but to the action of the pseudo-acid on the free tartaric acid. An overall equation might be written for example

$$4[C_4H_2O_6Fe\cdots H] + C_4H_6O_6 \longrightarrow 4(C_4H_4O_6)Fe + CO_2 + C_3H_2O_4$$

Ferritartaric acid.   Ferrous tartrate.   Glyoxalcarbonic acid.
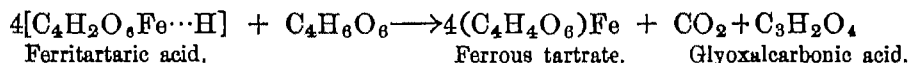
with dehydrogenation of the tartaric acid and formation of simple oxidation products. This type of reaction has been experimentally confirmed by exposing crystals of ferritartaric acid to sunlight in presence $M/10$ tartaric acid when the above reaction took place rapidly. There was no reaction in absence of free tartaric acid.

Manganese Complexes.—Manganic "alum" $Mn_2(SO_4)_3$, K_2SO_4, prepared by the method of Meyer and Best (*Z. anorg. Chem.*, 1899, **22**, 169) when added to solutions of sodium salts of various hydroxy-carboxylic acids, so as to contain 3·64 milliatom Mn^{+++} per litre (*i.e.*, in the same concentration as in the experiments with I_2) contained the Mn^{+++} in the form of a complex. This was shown by the fact that in some cases, particularly that of citrate, no iodine was liberated from KI, and in other cases slowly, whereas the original manganese alum instantly did so. Moreover, the latter rapidly hydrolysed to black insoluble H_2MnO_3 in presence of water, but no immediate hydrolysis took place in the presence of concentrated solutions of salts of hydroxy-carboxylic acids. All the solutions except citrate decomposed photochemically giving the products shown in Table I, column 5. With citrate there was a very slow thermal reduction, not accelerated by light. The rest were all stable in the dark over several days.

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In the presence of KI it was found that I_2 was liberated at variable measurable rates in the dark ; fastest with mandelate and lactate ; immeasurably slowly with citrate. Systems containing the latter gave no test for free I_2 under any of the following conditions :—

(*i*) Immediately after the addition of manganic alum, (*ii*) after highly diluting the mixture, (*iii*) after standing 24 hours in the dark, and (*iv*) after exposure to sunlight. On the other hand, if I_2 was added it was slowly used up in the dark.

FIG. 2.
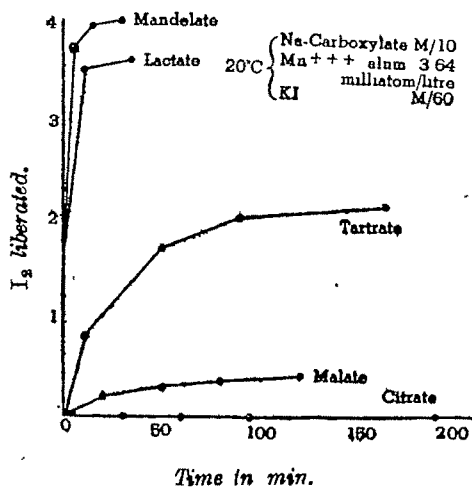
FIG. 3.
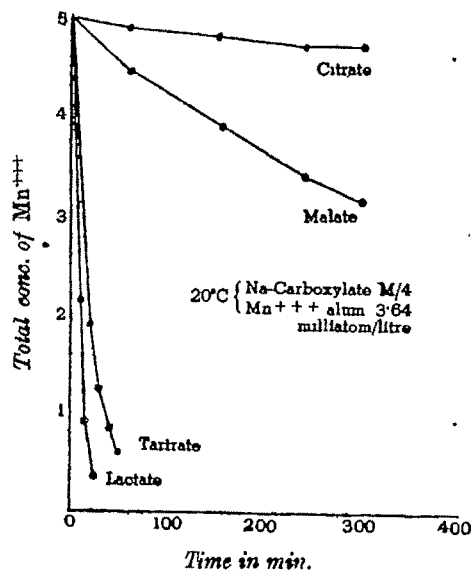
The relative rates at which the I_2 was liberated from these solutions is shown in Fig. 2. The slow and variable rates of reaction with KI explain the function of the complexes ; without their presence the metal in the higher state of valency would immediately be reduced by I′ present and thus no oxidation of the hydroxy-carboxylic acid would ensue.

Fig. 2 may be interpreted as follows, taking a dibasic acid as an example,

(*a*) $Mn^{+++} + \left[\text{hydroxycarboxylate}\right]^{--} \underset{\longleftarrow}{\longrightarrow} \begin{bmatrix} Mn^{+++} \\ \text{pseudo acid}\end{bmatrix} \underset{\longleftarrow}{\longrightarrow} \begin{bmatrix} Mn^{++} \\ \text{complex}\end{bmatrix}^{-} + 2H^+$

(*b*) $\begin{bmatrix} Mn^{+++} & \text{pseudo-acid}\end{bmatrix} + \begin{matrix}\text{hydroxy-carboxylic} \\ \text{acid}\end{matrix} \longrightarrow Mn^{++}\begin{matrix}\text{hydroxy-} \\ \text{carboxylate}\end{matrix} + \begin{matrix}\text{oxidation} \\ \text{products}\end{matrix}$

(*c*) $Mn^{+++} + \text{hydroxy-carboxylic acid} \xrightarrow{\text{photochemical}} \text{oxidation products} + Mn^{++}\text{salt}$
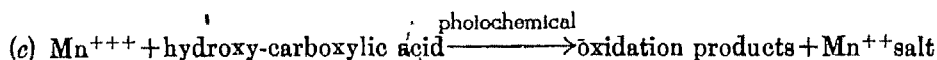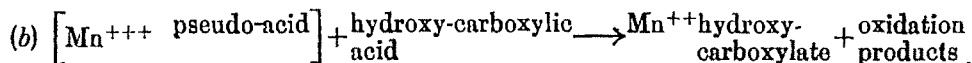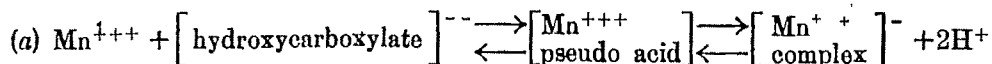
These relative rates of reaction with KI are therefore a measure of the rate of liberation of Mn^{+++} from the pseudo-acid in equilibrium (*a*) and the relative stability of the complex ions, since reduction of free Mn^{+++} by I′ is instantaneous.

In Fig. 3 are shown the relative rates of reduction when solutions containing manganic "alum" (3.64 milliatom of Mn^{+++} per litre) and $M/4$ sodium carboxylates are exposed to the light source. The course of reaction was measured by taking out from time to time a quantity of the mixture and adding it to a solution of KI acidified with HCl to destroy the complex. The amount of I_2 liberated gave a measure of the total Mn^{+++} present in the system at any time. Compared with Fig. 2 it is seen that citrate solutions, which contain no free Mn^{+++}, are photochemically stable, whereas lactate systems, which contain the largest relative concentration of available Mn^{+++}, are reduced photochemically at the fastest rate (Tartrate has been found to give different oxidation products in the light and in the dark ; a further detailed study of this reaction is in progress).

From these results, however, it seems permissible to infer that (i) the complex anions are stable both in the light and in the dark, (ii) the pseudo-acid is a powerful thermal oxidising agent, the action of which may or may not be subject to photochemical acceleration, (iii) photochemical oxidation results from interaction between free Mn^{+++} and the free carboxylic acid.

In our original experiments, since free Mn^{+++} cannot exist in the presence of KI, the rate-determining reaction must be the oxidation of the free carboxylic acid by the pseudo-acid complex ; and only those conditions which favour the maximum concentration of the latter will produce the maximum catalytic effects. So long as free I_2 is present we have the photo-process

$$I_2 + h\nu \longrightarrow I + I ; \qquad I + Mn^{++} \longrightarrow I' + Mn^{+++}$$

taking place, so that reduced Mn^{++} in (b) is instantly returned to the appropriate complex tervalent form.

The above mechanism has been proved in the case of citrate systems by starting with mixtures of sodium citrate, manganic alum and I_2 in the dark and gradually increasing $[H^+]$ by addition of free citric acid ; there is found an optimum $[H^+]$ corresponding to the maximum of pseudo-acid in equilibrium, at which tetraiodoacetone is formed at the maximum rate.

Relative Apparent Catalytic Efficiency of Iron and Manganese.—In Table I it will be observed that Mn^{++} is a much more efficient catalyst than Fe^{+++}, especially so in the case of citrate and malate. The difference between them resides in the fact that whereas the oxidation of free hydroxy-carboxylic acid by the ferri-acid is weakly photochemical with intensity of illumination experimentally employed, in the case of the mangani-acid there is more powerful thermal reaction.

This has been shown by taking two solutions containing equal concentration of sodium hydroxycarboxylate and free carboxylic acids with equivalent concentrations of Mn^{+++} and Fe^{+++} respectively and exposing them to the same light intensity. The total concentration of the metallic ions was measured from time to time and it was seen that the Mn^{+++} was reduced much more rapidly than Fe^{+++} under similar conditions. There is evidence, however, that the position of iron in the series (Table I, column 2) may be altered by varying the intensity of the incident light.

Although it has not been possible to carry out similar experiments with other metals, it is to be inferred from the above that the order of apparent catalytic activity of the ions, enumerated in Table I, is determined largely by the rate of reaction between the free complex acid and the free hydroxy-carboxylic acids.

Complexes of other metals.—The results obtained by adding chromic acid in equivalent quantity to the same concentrations of hydroxy-carboxylic acids is shown in Table I, column 6. The similarity in general behaviour to iron and manganese shows that here also corresponding complexes are formed, but it has not been possble so far to determine to what state of valency the Cr^{+++} ions, employed in our original expriments, has been raised, and what is the exact nature of the complexes formed with cobalt, cerium and uranium, the existence of hitherto unknown complexes containing these metals in a higher state of valency is also indicated.

Iodination products.—The iodination products formed from citrate, hexa- and tetraiodoacetone, and from malate and lactate, iodoform (Table I, column 3), are due to reaction between free I_2 and primary oxidation products of these acids ; in the case of citrate, acetone dicarboxylic acid ; lactate, pyruvic acid ; and malate, probably an isomer of pyruvic acid.

We have observed that free I_2 slowly disappears when added to solutions of sodium citrate and manganic alum in the dark, evidently by reaction with acetone dicarboxylic acid which is being formed. This explains the so-called photochemical "after-effect" in the sodium citrate-iodine reaction to which attention was called by Dhar (*J. Indian Chem. Soc.,.* 1925, **2**, 277).

CONCLUSIONS

1. The general reaction-mechanism may be represented in the manner already given under manganese complexes (*vide supra*). The I_2 dissociates photochemically producing the metal in a higher state of valency. The metal ions thus produced may react *photochemically* with the free hydroxy-carboxylic acid giving simple oxidation products ; the same products may also be obtained by *thermal* or *photochemical* reaction between the pseudo complex acid and the free hydroxy-carboxylic acid. The relationship between these two processes, which appears to be specific to each system, is the subject of further investigation.

2 A side reaction may take place between a metal ion M^{+++} and KI present in the solution, tending to set up another state

$$M^{+++}+I' \underset{\text{photochemical}}{\overset{\text{thermal}}{\rightleftharpoons}} M^{++}+I$$
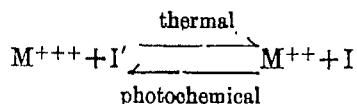
The rate of the forward reaction differs with different metals. The effect of the anionic metallic complex is to prevent this reaction occurring to any appreciable extent and to conserve the higher valency state of the metal in equation (*a*) (p. 266).

3. Inhibition of the reaction by increase in concentration of I′ is explained by shift of equilibrium in (ii) to the right, also by withdrawal of free I_2 in the equilibrium $I_2 + I' \xrightleftharpoons{} I_3'$; inhibition through increase of $[H^+]$ by shift of equilibrium in eqn. (a) (p. 266) to the left.

4. The kinetics of the apparent catalytic reaction and the order of comparative efficiency of the various metals employed, as measured by the rate of disappearance of I_2, is thus the net result of a number of simultaneous reactions of variable rates in (a, b, c, p. 268) and (ii). It has not been·found possible so far to give quantitative expression to the latter, so as to be able to predict the comparative catalytic efficiency of the metal ions with the light intensity applied.

5. The general similarity in the expreimental course of the reaction with all the metals employed indicates the existence of a number of co-ordination complex salts of hydroxy-carboxylic acids and manganese, chromium, cerium, cobalt and uranium, ʋraised to at least a tervalent state, which have not yet been described.

It may be noted in conclusion that attempts which have appeared in the literature to study these reactions in the absence of KI i.e., using I_2 in aqueous solution to commence with, apart from difficulties of measurement, do not appear to simplify the kinetics, since reaction, if it happens at all, is accompanied by the simultaneous production of I′.

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CHEMISTRY DEPARTMENT,
LUCKNOW UNIVERSITY,
LUCKNOW.

VELOCITY OF TRANSFORMATION OF 1 : 3 : 5 TRIKETONES INTO 2 : 6-DISUBSTITUTED γ-PYRONES. PART II

By W V. BHAGWAT, S. S. DESHAPANDE, C. W. SUBNIS AND S. G. HARMALKAR

Velocity of transformation of 1 : 3 : 5- triketones into γ-pyrones has been investigated and is found to be unimolecular like the standard substance, acetone dioxalic ester. It is therefore concluded that diacetylacetone and its homologues have open chain structure. The values of velocity constants depend on R-groups and is in the order : COOEt> CH_3>C_3H_7>C_2H_5. The high value due to COOEt is due to its negativity. The velocity constant for acetylbenzoylacetone, which contains one positive and one negative group, is intermediate between the negative COOEt group and the positive groups, CH_3, C_2H_5 and C_3H_7.

In Part I of this paper (*J. Indian Chem. Soc.*, 1940, **17**, 60) the authors have studied the velocity of transformation of acetonedioxalic ester into chelidonic ester with a view to investigating the structure of 1 : 3 : 5-triketones and obtained an unimolecular constant. The change is

$$
\underset{R'}{OC\!\!\begin{array}{c} \underset{\displaystyle |}{\overset{\displaystyle R}{}} \\ CH_2\!-\!CO \\ CH_2\!-\!CO \\ \underset{\displaystyle R'}{} \end{array}}
\qquad
OC\!\!\begin{array}{c} \overset{\displaystyle R}{} \\ CH=C-OH \\ CH=C-OH \\ \underset{\displaystyle R'}{} \end{array}
\;\longrightarrow\;
OC\!\!\begin{array}{c} \overset{\displaystyle R}{} \\ CH=C \\ CH=C \\ \underset{\displaystyle R'}{} \end{array}\!\!O
$$

(where R = R' = COOEt).
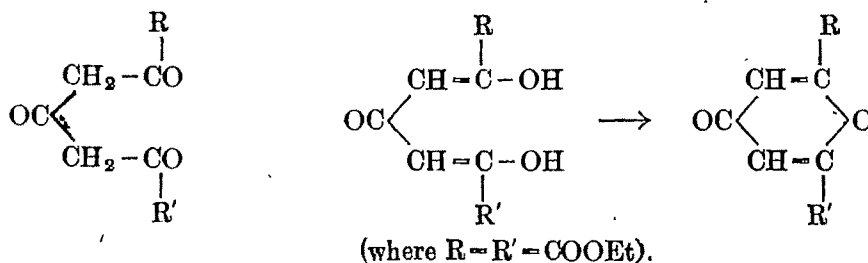
Diacetylacetone (R = R' = CH$_3$) and its homologues (R = R' = C$_2$H$_5$ or C$_3$H$_7$) under exactly identical conditions were found to behave exactly like the standard substance, giving 2:6-substituted dimethyl-, diethyl- and dipropyl-γ-pyrones. This supports independently the open chain structures of these compounds, verified chemically by Deshapande, Bedekar and Kaushal (*ibid.*, 1935, 12 465). In each case the reaction was found to be strictly unimolecular.

In case of acetone dioxalic ester, both physical and chemical methods were used for studying the rate of the reaction. However, with diacetylacetone and its homologues the physical method was found to be unsuitable because diacetylacetone is a low melting solid and its homologues are liquids, which are inconvenient for separation from medium and for weighing. The chemical method on the other hand was found to be satisfactory. These substances readily dissolve in 50% alcohol and copper salts are immediately precipitated by means of aqueous copper acetate solution. The pyrones formed are soluble in aqueous alcohol and hence are not precipitated. The copper salts were filtered at the pump, freed from the copper acetate by washing with water in which they are insoluble. It is observed that in all cases unimolecular constants are obtained, the reaction being as in the case of the standard substance, acetone dioxalic ester.

TABLE I

Velocity of transformation of diacetylacetone into dimethylpyrone.

Solvent = 50% aqueous methyl alcohol.   Catalyst = 0.0402 N-HCl.

Temp. = 52°. Wt. of diacetylacetone = 1.7386 g. Vol. of the soln. = 50 c.c.

Time (t)	Wt. of Cu-salt proportional to unchanged triketone $(a-x)$	$K_1 = \frac{1}{t}\log\frac{a}{a-x}$	Time (t)	Wt. of Cu-salt proportional to unchanged triketone $(a-x)$.	$K_1 = \frac{1}{t}\log\frac{a}{a-x}$
0 min.	0.1898 g.	—			
35	0.1726	0.00118	304 min.	0.0966 g,	0.00097
98	0.1567	0.00082	378	0.0820	0.00099
163	0.1310	0.00099	437	0.0748	0.00098
238	0.1104	0.00099	484	0.0652	0.00096

TABLE II

Velocity of transformation of dipropionylacetone into diethylpyrone.

Wt. of dipropionylacetone = 0.4874 g. Vol. = 50 c.c. Vol. of soln. precipitated as Cu salt each time = 4 c.c. Other conditions same as in Table I.

t.	$a-x$.	k_1.	t.	$a-x$.	k_1
0 min.	0.0454 g.	—	321 min,	0.0320 g.	0,00048
60	0.0424	0,00049	375	0.0304	0,00047
178	0.0372	0,00048	471	0,0288	0,000 5

TABLE III

Solvent = 80% aqueous methyl alcohol. Catalyst = 0.1036 N-HCl. Temp. = 62°. Wt. of dipropionyl acetone = 0.8782 g. Vol. = 25 c.c. Vol. ppted each time = 2 c.c.

t.	$a-x$.	k_1.	t.	$a-x$.	k_1.
0 min,	0.09897 g.	—	195 min.	0.0288 g.	0.0027
48	0.0698	0,0027	253	0.0178	0,0028
87	0.0548	0,0027	318	0.0114	0 0029
188	0,390	0.0028	355	0.0082	0,0029

TABLE IV

Velocity of transformation of di-n-butyrylacetone into di-n-propylpyrone.

Solvent = 50% aqueous methyl alcohol. Catalyst = 0.402N-HCl. Temp. = 52°. Wt of di-n-butyrylacetone = 0.3628 g. Vol. of the solution = 50 c.c. Vol. of the soln. ppted each time = 4 c.c.

t.	$a-x$.	k_1.	t.	$a-x$.	k_1.
0 min.	0.0314 g.	—	326 min.	0.0206 g.	0.00056
70	0.0282	0,00059	471	0.0168	0.00057
215	0.0238	0.00056	585	0.0148	0.00057

TABLE V

Velocity of transformation of acetylbenzoylacetone into 2-methyl-6-phenylpyrone.

Solvent = 80% aqueous methyl alcohol. Catalyst = 0.040-N-HCl. Temp. = 60°. Wt. of acetylbenzoylacetone = 0.6068 g. Vol. of the soln. = 100 c.c. Vol. of soln. ppted each time = 10 c.c.

t.	$a-x$.	k_1.	t.	$a-x$.	k_1.
0 min.	0.0746 g.	—	240 min.	0.0194 g.	0.00243
60	0.0498	0,00291	300	0.0150	0.00242
120	0.0380	0.00244	360	0.0084	0,00280
180	0.0276	0.00240			

Comparison of the values of k_1 determined with the groups in the above reactions is given below :

TABLE VI

Groups	$CO_2Et.$ and CO_2Et	CH_3 and C_6H_5	CH_3 and CH_3	C_3H_7 and C_3H_7	C_2H_5 and C_2H_5
k_1	0.0325	0.0024 (60° solvent 80% MeOH)	0.00096	0.00058	0.00048

The above table shows that the velocity constant as dependent on groups R are in the following order :—COOEt $>$ CH$_3$ $>$ C$_3$H$_7$ $>$ C$_2$H$_5$, the very high value of the velocity constant due to the group COOEt is doubtless due to its acidic character. The velocity constant does not seem to depend on the weight of the group only, for the effect of C$_3$H$_7$ group is greater than that of C$_2$H$_5$. It appears that COOEt group, which is a negative group, confers maximum velocity to the reaction. All other remaining groups are positive. An interesting case arises when a triketone contains one positive and one negative group. This was realised in the case of acetylbenzoylacetone (R—CH$_3$, R'—C$_6$H$_5$) which changes into 2-methyl-6-phenylpyrone.

Here the velocity constant of the reaction, which was carried out under the same conditions as the other reactions as far as possible, was found to be less than for acetone dioxalic ester but greater than that for diacetylacetone.

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STUDIES IN SULPHANILAMIDES. PART III. N¹-AND N⁴-SUBSTITUTED SULPHANILAMIDES, SCHIFF'S BASES OF SULPHAPYRIDINE AND SULPHATHIAZOLE*

BY K. R. DORASWAMY AND P. C. GUHA

Eighteen Schiff's bases of sulphapyridine and sulphathiazole have been prepared.

In the course of the development of the chemotherapy of sulphanilamide and its derivatives, Schiff's bases have not received much attention from investigators, even though Goissedet, Despois, Galliot and Mayer (*Compt. rend. Soc. Biol.*, 1936, **121**, 1082) announced as early as 1936, that the Schiff's bases of sulphanilamide derived from benzaldehyde and some substituted benzaldehydes were active. This result was confirmed by Buttle, Gray, and Stephenson (*Biochem. J.*, 1937, **31**, 724) who prepared and tested the anils of sulphanilamide derived from *m*-nitro-, 6-nitro-, 3-hydroxy- and *p*-methoxy-benzaldehydes, cinnamic aldehyde, veratraldehyde, 3 : 4-diethoxybenzaldehyde and *p*-dimethylaminobenzaldehyde ; and in addition they reported that they were much less toxic. The next set of workers, Kolloff and Hunter (*J. Amer. Chem. Soc.*, 1940, **62**, 158) extended this field to N¹-substituted sulphanilamides, and prepared and tested a few anils of sulphapyridine also. All these workers found that the introduction of any arylidine group into the N⁴-nitrogen did not very much alter the bactericidal property, but the toxicity was considerably diminished. However, the anils derived from *p*-nitrobenzaldehyde (*Chem. Rev.*, 1940, **27**, 85) have been reported to be more active than the free amino compounds. The few anils of sulphapyridine that have been made so far by Kolloff and Hunter, viz. those of benzaldehyde, cinnamaldehyde, 2-nitro-, 4-nitro-, 3-hydroxy-, *p*-methoxy- and *p*-dimethylamino-benzaldehydes have all been found to possess good therapeutic properties and low toxicity. Apart from these few anils of sulphapyridine, no systematic investigation seems to have been undertaken on the study of the Schiff's bases of the two well reputed drugs, viz., sulphathiazole and sulphapyridine. It therefore seemed of interest to synthesise a series of Schiff's bases of a sulphathiazole and sulphapyridine using particularly those aldehydes which have proved effective in the case of similar compounds derived from sulphanilamide itself.

The usual method of preparation of the Schiff's bases is by reacting molecular proportion of the aldehyde and the sulphanilamide compound in boiling alcoholic solution as indicated by Buttle, Gray and Stephenson (*loc. cit.*). But after many trials the best method has been found to be the direct fusion of the appropriate aldehyde with the sulphanilamide at about 150-160° in an oil-bath. However, in the case of phenylacetaldehyde and furfuraldehyde, the condensation is easily effected in alcoholic solution. The alcoholic solution on warming under vigorous shaking deposits the anil.

As these Schiff's bases are insoluble in the usual organic solvents, their purification offers considerable difficulty. Many of these compounds are simply ground in alcohol several times so as to dissolve any unreacted starting material filtered off, washed and dried. They are all coloured crystalline compounds, with, sharp melting points and low solubility in water and are easily hydrolysed by weak acids. The results of their pharmacological examination are awaited.

EXPERIMENTAL

The anils from all the aldehydes except from those of furfuraldehyde and phenylacetaldehyde were prepared by the general procedure described for benzylidine-sulphanilamidothiazole.

Preparation of Benzylidine-sulphanilamidothiazole.—Sulphathiazole (1 g.) and pure redistilled benzaldehyde (0.5 g) were mixed in a small round-bottom flask fitted with an air condenser and the mixture was heated in an oil-bath at $150° - 160°$ for 3 hours. The mixture first melted and gradually became a pasty mass with small particles of water condensing on the cooler sides of the condenser. This was removed by applying gentle suction. After heating for 3 hours, the product was cooled and mixed with water. The solid was broken up and ground in a mortar to a fine powder and filtered and washed with water and alcohol, yield 1.2 g. (90% of theory), m.p. 202°.

The anils from furfuraldehyde and phenylacetaldehyde were prepared by mixing the molecular proportions of sulphathiazole (or sulphapyridine) and the aldehyde in alcoholic solution and slightly warming on a water-bath. The anils separated in fine yellow crystals.

The compounds prepared are listed in Table I.

TABLE I

		Anils of sulphathiazole $ROH : N.C_6H_4. SO_2NH-C$ (N—OH, OH, S)			Anils of sulphapyridine $N.C_6H_4. SO_2NH-$ (N), CHR		
R.	Aldehyde used.	M.p.	Nitrogen % Found.	Theo :	M.p.	Nitrogen % Found.	Theo
C_6H_5	Benzaldehyde	202°	12.02	12.25	240°	12.27	12.47
p-OMe-C_6H_4-	Anisaldehyde	160°	11.87	11.23	205°	11.79	11.44
(3) OH,(4) OMe. C_6H_3-	Vanillin	245°	10.57	10.80	146-47°	10.84	10.96
3 : 4-$(OMe)_2C_6H_3$-	Veratraldehyde	138°	10.15	10.42	210°	10.86	10.55
$C_6H_5 . CH=CH$	Cinnamaldehyde	260°	11.25	11.38	210°	10.91	11.42
C_4H_3O-	Furfuraldehyde	chars at-210°	12.40	12.61	214°	12.37	12.84
m-$NO_2. C_6H_4$-	m-Nitro-benzaldehyde	231°	14.20	14.43	254°	15.12	14.65
m-Cl. C_6H_4	m-Chloro-benzaldehyde	124°	10·84	11.13	101°	11.48	11.24
$C_6H_5. CH_2$-	Phenyl-acetaldehyde	164°	11.77	11.76	100° (decomp.)	11.84	11.96

STUDIES IN SULPHANILAMIDES. PART IV. N^1-AND N^4-SUBSTITUTED SULPHANILAMIDES, ACYCLIC ACYL DERIVATIVES OF SULPHATHIAZOLE AND SULPHAPYRIDINE

By K. R. Doraswamy and P. C. Guha

Sixteen aliphatic acyl derivatives of sulphapyridine and sulphathizole have been prepared.

Although Fourneau *et al* (*Compt. rend. Soc. Biol.*, 1936, **122**, 258) announced in 1936, that the therapeutic activity of sulphanilmide was greatly reduced by the introduction of an acyl group on the 4-amino nitrogen, several investigations (Buttle and Gray, *Lancet* 1936, I, 1296 ; Adams, Long and Johnson, *J. Amer. Chem. Soc.*, 1939, **61**, 2342, 2346 ; Trefouel, Nitti, *et al.*, *Ann. Inst. Pasteur*, 1937, 58, 30) have been undertaken on the synthesis and therapeutic evaluation of the N^4-acyl derivatives. Three years after this announcement, Miller, Rock and Moore (*J. Amer. Chem. Soc.*, 1939, **61**, 1198) by a systematic study of the N^4-acyl derivatives of sulphanilamide found that the caproyl derivative was as effective as sulphanilamide itself and also less toxic. They found that (*i*) the monocarboxylic acid derivatives were more effective than those of the dicarboxylic acids ; (*ii*) among the monocarboxylic acid derivatives the activity increased with the increase in length of the acyl groups up to 6-carbon atoms, after which it decreased rapidly ; and that (*iii*) the *normal*-acyl derivatives were more active than the corresponding *iso*-derivatives. Generally all these investigators found that the toxicity of the acyl derivatives was much lower than that of sulphanilamide.

The long-chain fatty acids, particularly those derived from chaulmoogra and hydnocarpus oils, have been successfully used in the treatment of leprosy and tuberculosis. So, it was expected that the range of therapeutic usefulness of the acyl sulphanilamides derived from these fatty acids would be extended further to include these acid-fast mycobacteria, viz. those of tubercular and leprous bacilli. With this end in view, Bargmann and Heskelberg (*J. Amer. Chem Soc.*, 1941, **63**, 2243) and Rajagopalan (*Curr. Sci.*, 1942, **11**, 394) have synthesised some N^4-acyl derivatives from straight chain fatty acids, the therapeutic properties of which have not yet been reported.

The presence of the grouping $H_2N . C_6H_4 . SO_2NH$-is considered to be of fundamental physiological significance from the standpoint of the existing theories of the mode of action of sulphanilamide drugs, and any stable structural alteration in this group has been known to destroy the therapeutic activity. So, it may be thought that the N^4-acyl derivatives may not possess any therapeutic activity at all on the ground that the amino group is blocked in their molecules. However, it is known that some of the acyl derivatives of sulphanilamide are hydrolysed *in vivo* to the respective sulphanilamide (Kohl and Flynn, *Proc. Soc. Biol. Med.*, 1940, **44**, 445 ; Bradbury and Jordan, *Biochem. J.*, 1942, **36**, 287). So it may be expected that the N^4-acyl derivatives of sulphapyridine and sulphathiazole will

possibly undergo the cleavage giving rise to the original sulphathiazole or sulpha-pyridine *in vivo*. Further, in such liberation of the parent compound *in vivo*, in addition to the sulphanilamide, simultaneously the fatty acids also will be liberated. So it was thought to be of interest to ascertain whether the presence of these fatty acids will have any influence on the therapeutic activity of the free amino compound.

While numerous acyl derivatives of sulphanilamide have been prepared, no systematic study seems to have been made on the acyl derivatives of sulpha-pyridine and sulphathiazole. Considerations such as these led to the synthesis of the N^4-acyl derivatives of sulphapyridine and sulphathiazole from the following fatty acids : formic, acetic, propionic, butyric, *iso*valeric, caprylic, nonylic and capric. The caproic and heptoic acids were not available in these laboratories, and so the derivatives corresponding to those acids could not be studied.

The preparation of these acyl derivatives is usually effected by the action of acid chlorides or anhydrides (or in some cases, the acids themselves) on sulphanit-amide. In the present work, however, mostly acid chlorides were employed, the formyl derivative having been prepared from ethyl formate. The acid chlorides were prepared by the action of thionyl chloride on the acids. The reaction between the acid chlorides and the sulphapyridine (or sulphathiazole) was carried out in boiling pyridine solution. The reaction mixture on treatment with excess of water gave the acyl derivatives, which were purified by precipitation by acid from their dilute sodium hydroxide solution and further by recrystallisation from alcohol.

The melting points of these acyl derivatives are not sharp in spite of repeated crystallisations. They are all white amorphous powders, sparingly soluble in water. The result of their pharmacological examination is eagerly awaited.

EXPERIMENTAL

The formyl derivatives were prepared by refluxing sulphathiazole or sulpha-pyridine with excess of ethyl formate. On refluxing for 4 to 5 hours the sulpha-thiazole (or sulphapyridine) gradually dissolved giving rise to a pale red solution. The excess of ethyl formate was removed by evaporation, and the solid left behind was washed with water and alcohol, and purified by crystallisation from alcohol.

The other acyl derivatives were prepared by the following general method described for propionylsulphathiazole.

Preparation of Propionylsulphathiazole.

$$CH_3CH_2CO \cdot NH \cdot C_6H_4 \cdot SO_2NH-C \underset{S}{\overset{N-CH}{\underset{\diagdown \diagup}{\mid \mid}}} CH$$
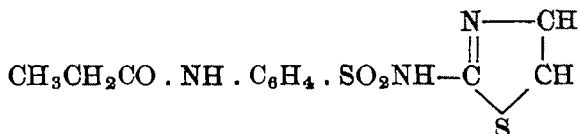
Sulphathiazole (1g.) was dissolved in pyridine and propionyl chloride (1 c. c.) was added. The mixture was heated under reflux for about 1 hour and the resulting product on dilution with excess of water gave the acyl derivative.

This was filtered and purified by dissolving in sodium hydroxide solution and reprecipitating by acidification. The precipitated product was filtered off, washed with water and alcohol, dried and weighed (1. 2 g.), m. p. 245°.

TABLE I

R.	Acid used.	Acyl derivatives of sulpha-thiazole.			Acyl derivatives of sulpha-pyridine.		
		M.p.	Nitrogen % Found.	Theo :	M.p.	Nitrogen % Found.	Theo :
H	Formic	215°	15.04	14.84	205°	15.33	15.16
CH_3-	Acetic	256°	...	...	225°	...	...
$CH_3.CH_3$-	Propionic	245°	12.98	13.50	217°	14·13	13·77
$CH_3(CH_3)_2$-	Butyric	250°	13.04	12.92	165°	12.31	13.16
CH_3 >CH . CH_3 CH_3	isoValeric	190°	12.47	12.39	191-2°	13.03	12.61
$CH_3(CH_2)_6$	Caprylic	214°	11.28	11·03	210°	11.33	11.20
$CH_3(CH_2)_7$	Nonylic	189°	10.71	10·68	186°	11.01	10·80
$CH_3(CH_2)_8$	Capric	142°	10.37	10.27	160°	10.15	10.42

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STUDIES IN SULPHANILAMIDES. PART V. N¹-AND N⁴-SUBSTITUTED SULPHANILAMIDES. N⁴-ISO CYCLIC ACYL DERIVATIVES OF SULPHATHIAZOLE AND SULPHAPYRIDINE

BY K. R. DORASWAMY AND P. C. GUHA

Sixteen iso-cyclic acyl derivatives of sulphathiazole and sulphapyridine have been prepared.

Although much work has been done on the study of the N⁴-acyclic acyl derivatives of sulphanilamides, it is surprising that only a very few derivatives from aromatic acids have been reported so far and among them only the p-nitrobenzoyl derivative is reported to be as active as sulphanilamide itself, and the benzoyl derivative is reported to be inactive. Further, no corresponding derivatives of sulphathiazole and sulphapyridine have so far been made. Therefore, it was considered worth while to prepare a few derivatives of these two drugs with some very common aromatic acids.

These acyl derivatives were prepared by the action of the appropriate acid chloride on sulphathiazole or sulphapyridine in aqueous alkaline solution. The acid chlorides required for this work were prepared by the action of thionyl chloride on the corresponding acids without the use of a solvent The condensation products were purified by crystallisation from alcohol. They are usually colourless amorphous powders, without sharp melting point and low solubility in water. Their pharmacological examination is awaited.

EXPERIMENTAL

The following general procedure was followed for the preparation of the derivatives.

Preparation of Benzoylsulphathiazole.—Sulphathiazole (1 g.) was dissolved in 5 c.c. of sodium hydroxide (5%) and benzoyl chloride (0·6 c.c.) was added with good shaking in two or three portions. After each addition the mixture was well shaken. The product separating from the alkaline solution was left to stand for 2 hours with occasional shaking. Then the product was made acidic, and the precipitated benzoyl derivative was filtered off, washed several times with water and alcohol, dried and weighed, yield 1.2 g. Recrystallised from dilute alcohol, m.p. 250-51°.

TABLE I

R	Acid used.	Isocyclic acyl derivatives of sulphathiazole.			Isocyclic acyl derivatives of sulphapyradine.		
		M.p.	Nitrogen % Found.	Theo :	M.p.	Nitrogen % Found.	Theo :
C_6H_5-	Benzoic	250-51°	11.66	11.69	245-6°	11.98	11.90
p-Cl-C_6H_4-	p-Chlorobenzoic	240°	10.96	10.67	238°	11.27	10.83
p-Br-C_6H_4-	p-Bromobenzoic	263°	9.22	9.58	215°	9.62	9.72
p-NO_2-C_6H_4-	p-Nitrobenzoic	265°	14.04	18.98	258°	13.87	14.09
p-OMe-C_6H_4-	p-Methoxybenzoic	185-6°	10.64	10.80	165-6°	11.50	10.96
$C_6H_5.CH=CH$-	Cinnamic	253°	10.92	10.91	235°	11.11	11.09
$C_6H_5.CH_2$-	Phenylacetic	143-5°	11.66	11.26	189°	11.45	11.44
p-$CH_3.C_6H_4$-	p-Toluic	265°	11.43	11.26	197-8°	11.13	11.44

STUDIES IN SULPHANILAMIDES. PART VI. N^1-AND N^4 SUBSTITUTED SULPHANILAMIDES-AZO-DYES DERIVED FROM SULPHATHIAZOLE AND SULPHAPYRIDINE

BY K. R. DORASWAMY AND P. C. GUHA

Twentysix azo-dyes have been prepared by diazotizing sulphathiazole and sulphapyridine and coupling with aromatic hydroxy and amino compounds.

Although it has not yet been fully proved, the opinion concerning the mode of action of the prontosils (the azo-dyes derived from sulphanilamide) is believed to be the result of the reductive cleavage of the azo-linkage *in vivo*, giving rise to sulphanilamide, which in turn is responsible for the antistreptococcal property.

Further, when these azo-dyes undergo reduction *in vivo*, they give rise not only to sulphanilamide but also to aminophenols and aromatic polyamines. It is known that these aminophenols and aromatic polyamines are oxidised in the system giving rise *in vivo* to quinonoid bodies (Tischler *et al., J. Amer. Chem. Soc.,* 1940,

62, 1881 ; Doisy *et al., Chem. Rev.,* 1941, **28,** 477) and further many synthetic and natural quinones are in use as antibacterial agents (Raistrack *et al., Chem. &Ind.,* 1941, **60,** 828; 1942, **61,** 22, 48 128, 485). Some quinones occur in some bacteria and in addition are known to constitute essential growth factors (Woolley and McCarter, *Proc. Expt. Biol. Med.,* 1940, **45,** 357) for many types of bacteria. So it will be of interest to study whether these quinonoid bodies have any influence on the activity of the sulphanilamides. Further, it has been observed by Gley and Gerard (*Pressa. Med.,* 1936, **42,** 1775) that whereas molecular equivalents of prontosil and sulphanilamide are of equal therapeutic potency, the carboxy derivative of prontosil is twice as effective as prontosil, even though molecular proportions of prontosil and its carboxy derivative may give rise only to equal amounts of sulphanilamide. Then again, the azo-dyes prepared from diazotised sulphanilamide with resorcinol, 3 : 5-diaminobenzoic acid, *p*-hydroxyphenylglycine and histidine, pyrrole and indole and some purines (Northey, *Chem. Rev.,* 1940, **27,** 85) are reported to be more active than sulphanilamide itself.

A review of the existing literature on the sulphonamide-azo-dyes shows that, though a considerable number of them has been reported, no data of their therapeutic activity is given. Further, only very few azo-dyes of sulphathiazole and sulphapyridine have been studied in detail in respect of their bactericidal activity. It was therefore considered desirable to synthesise a series of azo-dyes of sulphathiazole and sulphapyridine with common phenols and amines which have been found to be effective when coupled with diazotised sulphanilamide.

The results of their pharmacological examination are awaited.

The following azo-dyes have been prepared :

TABLE I

RH Name of phenol (amine) coupled with	Azo-dyes derived from sulphathiazole.			Azo-dyes derived from sulphapyridine		
	Colour.	Nitrogen % Found.	Calc.	Colour.	Nitrogen % Found.	Calc.
(a) *Phenolic azo-dyes*						
Phenol	Red	15.69	15.55	Dark red	15.46	15.82
p-Cresol	,,	15.23	14.97	,, ,,	15.16	15.22
Resorcinol	,,	15.2₀	14 89	Brick		
Resorcinol mono- methyl ether	Brick red	14.01	14.35	red	15.26	15.14
				,, ,,	14.36	14.58
1 : 2 : 5-Xylenol	Dark red	14.62	14.43	,, ,,	14 36	14.66
Salicylic acid	,,	13.69	13.87	,, ,,	14.76	14.51
β-Naphthol	Brown	13.57	13.66	,, ,,	13.87	13.87
α-Naphthol	,,	13.54	13.66	,, ,,	13.58	13.87
(b) *Aminoazo-dyes*						
Dimethylaniline	Dark red	17.74	18.09	Dark red	18.16	18.38
m-Phenylene- diamine	,, ,,	22.71	22.46	,, ,,	22.32	22.83
Anthranilic acid	Yellow	17.20	17.87	Yellow	17.81	17.63
β-Naphthylamine	Dark red	16.91	17.12	Dark red	17.18	17.37
Naphthionic acid	Brick red	13.87	14.37	Brick red	14.39	14.46

EXPERIMENTAL

The general procedure adopted for the preparation of phenolic azo-dyes is illustrated in the preparation of the azo-dye derived from diazotised sulphathiazole and phenol.

4-Hydroxy-(p-*N^1-2-thiazolyl-sulphamyl.*

$$HO\text{—}\langle\rangle\text{—}N:N-C_6H_4-SO_2NH.C\underset{S}{\overset{N-CH}{\diagdown\diagup}}CH$$
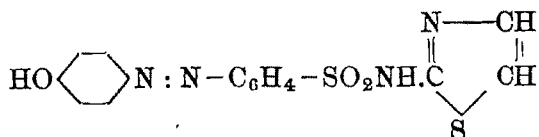
Sulphathiazole (1 g.) was dissolved in 3 c. c. of 10 % sodium hydroxide and the solution cooled in ice. 10 % Sodium nitrite solution (also well cooled, 5 c.c.) was added with shaking and the resulting mixture cooled to 0°. This was added on to a mixture of 5 c. c. of 10 % HCl and ice, with stirring, when a fine yellow precipitate resulted. This was allowed to stand over with occasional shaking for 15 minutes. Phenol (0. 5 g.) was dissolved in 10 c. c. of 10 % sodium hydroxide and cooled to 0° in ice, and the diazonium solution was added on to this with good stirring when a brown-red solution resulted. This was allowed to stand for 2 hours with occasional shaking, and acidified with hydrochloric acid when the dye was precipitated. The dye was purified by dissolving in sodium hydroxide solution and reprecipitating by acidification as red powder, yield 1.2 g.

The general procedure adopted for the preparation of amino-azo dyes is illustrated in the preparation of the *azo-dye* derived from diazotised sulphathiazole and dimethylaniline.

4-Dimethylamino-(p-*N^1-2-thiazolyl-sulphamylphenyl-azo*)-*benzene.*

$$(CH_3)_2N\text{—}\langle\rangle\text{—}N:N\langle\rangle\text{—}SO_2NH.C\underset{S}{\overset{N-CH}{\diagdown\diagup}}CH$$
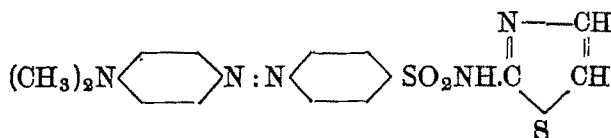
Sulphathiazole (1 g.) was dissolved in sodium hydroxide solution (3 c. c. of 10 %) and cooled in ice. Sodium nitrite solution (5 c. c. of 10 %) was next added with good shaking and the mixture cooled to 0°. This was added on to 5 c. c. of 10 % hydrochloric acid and ice with good stirring and the resulting yellow precipitate was allowed to stand for 15 minutes. Dimethylaniline (0.5 c. c.) was shaken with 2 c. c. of hydrochloric acid (10%) and diluted with water and cooled to 0°. The diazotised sulphathiazole was added on to this with good stirring. A solution of 5 g. of sodium acetate in 10 c. c. of water was added with good shaking and the dark red solution allowed to stand overnight. Next day, the product was made alkaline and the dye was filtered off, washed with water, and purified by dissolving in sodium hydroxide solution and reprecipitating by acidification, yield 1.2 g.

STUDIES IN SULPHANILAMIDES. PART VII.

N^1-AND N^4-SUBSTITUTED SULPHANILAMIDES : N^4-SULPHONYL DERIVATIVES OF SULPHAPYRIDINE AND SULPHATHIAZOLE

By K. R. Doraswamy and P. C. Guha

Ten aromatic sulphonyl derivatives of sulphathiazole and sulphapyridine have been prepared.

Special interest attaches to sulphanilamide (A) and to the related group of sulphonyl derivatives.

$$NH_2 \langle \rangle - SO_2NH - \langle \rangle SO_2NH_2$$
$$(A)$$
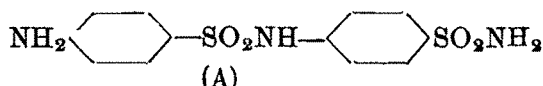
The therapeutic effect of (A) reported simultaneously by a number of investigators. (Fourneu and co-workers, *Compt. rend. Soc. Biol.*, 1936, **122**, 258) studied the therapeutic effect of N^4-(acetylsulphanilyl-) sulphanilamide,

$$CH_3CONH \langle \rangle - SO_2NH - \langle \rangle SO_2NH_2$$
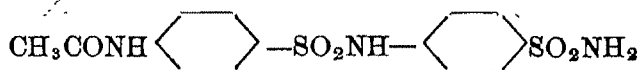
and reported as having only very little potency.

Further work along this line was continued by Crossley and Northey (*J. Amer. Chem. Soc.*, 1938, **60**, 2222) who synthesised the sulphanilyl derivatives of a number of N^1-substituted sulphanilamides. They found that the addition of a sulphanilyl group to the amino group increased the activity still further. However, a good contrast was afforded by N^3-sulphanilyl metanilamide

$$NH_2 \langle \rangle - SO_2NH \langle \rangle$$
$$SO_2NH_2$$
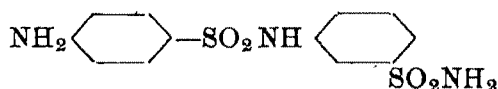
which was found to be more active than N^4-metanilyl sulphanilamide

$$NH_2$$
$$\langle \rangle - SO_2NH \langle \rangle SO_2NH_2$$
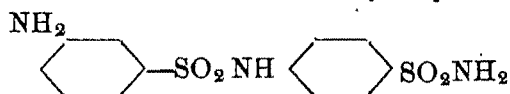
the first compound behaving as N^1-metanilamide substituted sulphanilamide, while the second as N^4-metanilamide substituted sulphanilamide.

Sprague, McBurney and Kissinger (*J. Amer. Chem. Soc.*, 1940, 62, 1714) extended this work further by preparing a few N^4-sulphonyl derivatives, other than sulphanilyl with some alkyl sulphonic acids. They found that the introduction of a sulphonyl group into the N^4 position of the sulphanilamide molecule markedly reduced the activity, the toxicity getting reduced at the same time as compared with that of sulphanilamide.

Thus in general it is found that the introduction of a sulphonyl group at N^4 position reduces the activity, except in the case of N^4-sulphanilyl derivatives which may be looked upon as N^1-substituted sulphanilamides with the free amino group in the *p*-position. The toxic effect of these sulphonyl derivatives is, however, very much·lower than that of the parent compound. Further, though a few such derivatives of sulphanilamide itself have been prepared, similar derivatives of the two famous drugs, *viz.*, of sulphathiazole and sulphapyridine have not been prepared so far. These considerations led us to synthesise a few aryl sulphonyl derivatives of sulphapyridine and sulphathiazole, which are listed in the table. Among these derivatives sulphanilyl sulphathiazole (I) and sulphanilyl sulphapyridine (II) are of special significance as they are expected to possess good therapeutic activity.
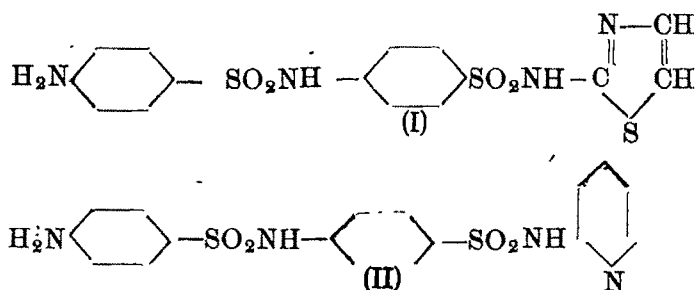
The preparation of these derivatives was effected by the action of the respective sulphonyl chlorides on sulphapyridine or sulphathiazole in aqueous alkaline solution as detailed in the experimental part. The respective benzene and toluene sulphonyl chlorides were prepared by the action of chlorosulphonic acid on benzene and toluene. The sulphanilyl derivatives were prepared by reacting *p*-acetsulphanilyl chloride on sulphathiazole or sulphapyridine, followed by hydrolysis of the acetylsulphanilyl derivative.

The compounds were purified by crystallisation from alcohol. They are all colourless amorphous compounds with sharp melting points and sparing solubility in water. The pharmacological examination is awaited.

EXPERIMENTAL

The compounds prepared are described in the Table I.

Table I.

$$R . SO_2NH\langle\ \rangle-SO_2NH-C\underset{S}{\overset{N-CH}{\overset{\|}{\underset{}{\text{—}}}}\overset{\|}{CH}}$$

$$R.SO_2NH\langle\ \rangle-SO_2NH.C\underset{N}{\overset{}{\|}}$$

Sulphathiazole derivative   Sulphapyridine derivative

R	Name of sulpho-nic acid used.	Sulphonyl derivatives of sulphathiazole.			Sulphonyl derivatves of sulphapyridine.		
		M.p.	Nitrogen		M.p.	Nitrogen	
			Found.	Theo.		Found.	Theo.
C_6H_5	Benzene	189°	10.13%	10.63%	230°	10.67%	10.88%
$CH_3.C_6H_4$-	p-Toluene	172°	10.92	10.27	160°	10.73	10.42
p-CH_3CONH-C_6H_4-	p-Acetamino-benzene	128-30°	12 92	12.39	145-46°	12.34	12.39
p-NH_2-C_6H_4-	p-Amino-benzene	210°	13.62	13.65	236°-38°	13.35	13.90
m-$NO_2.C_6H_4$-	m-Nitrobenzene	175°	12.54	12.69	185°	11.85	12.90

The benzene, toluene, p-acetaminobenzene and m-nitrobenzene sulphonyl derivatives were prepared by the following general procedure.

Preparation of Benzenesulphonyl sulphathiazole.—Sulphathiazole (1g.) was suspended in water and to the mixture gradually added drop by drop 2 c.c. of benzene sulphonyl chloride (freshly distilled) with good shaking. After each addition of the sulphonyl chloride a few drops of 10% sodium hydroxide were added with good shaking, maintaining the solution feebly alkaline throughout.

After the addition was over, the product was allowed to stand with occasional shaking for 2 hours, and the separated solid was filtered off, washed with water and alcohol, dried and crystallised from alcohol, m.p. 189°, yield 1.2g.

The sulphanilyl derivatives were prepared by hydrolysis of the corresponding acetsulphanilyl derivatives with 10% hydrochloric acid as usual.

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INVESTIGATIONS ON HYPONITRATES. PART I.
SODIUM AND POTASSIUM HYPONITRATES

By K. G. Naik, C. C. Shah and S. Z. Patel

Sodium and potassium hyponitrates have been prepared successfully and their chemical reactions studied.

Although hyponitric acid ($H_2N_2O_3$) called nitrohydroxylaminic acid by Angeli (*Gazzetta*, 1896 **26**, *ii*, 17,) and its salts (nitrohydroxylaminaminates) are known to exist, there is not much information available on their properties.

The sodium and potassium hyponitrates required for the present work were prepared by a modification of the method used by Angelico and Fauara (*Gazzetta*, 1901 **31**, *ii*, 21). The potassium salt gives well defined and large crystals and is more hygroscopic than the sodium salt, but is always contaminated with considerable quantities of nitrite and nitrate. The above workers obtained it as $K_2N_2O_3$, while our results show it to be $K_2N_2O_3 . H_2O$.

Action of Air, Saturated Aqueous Vapour, and Dry Carbon Dioxide.— -Angeli and co-workers (*ibid.* 1900 **30**, 593) found that when sodium hyponitrate is exposed to air, rapid absorption of oxygen takes place forming sodium nitrite, which in presence of excess of hyponitrate partially undergoes further oxidation to nitrate. We have found that if sodium hyponitrate is exposed to air, it rapidly absorbs moisture and increases in weight. After a certain time (about seven days), it begins to lose weight. If it is exposed to water vapour in a desiccator containing water, the increase in weight continues for a considerable time, but the weight immediately begins to fall on exposure to free air. If the dry salt is exposed to dry carbon dioxide (over sulphuric acid) in a desiccator, the weight remains unchanged. A sample exposed in this manner for about a fortnight, was found to undergo negligible change in weight. It gave with silver nitrate solution a black precipitate, characteristic of hyponitrates, whereas that salt after exposure to air or water vapour did not give this test, showing the absence of hyponitrate in the latter. If a sample of sodium hyponitrate is exposed to *dry* air instead of moist or ordinary air the salt does undergo the same changes but the rate of decomposition is very slow.

It appears that the dry salt is unaffected by carbon dioxide and is hygroscopic but in contact with water vapour or in solution, it is slowly decomposed into nitrite, nitrate, and carbonate.

Action of Water.—An aqueous solution of sodium hyponitrate decomposes on standing forming nitrite with the liberation nitrous oxide

$$2Na_2N_2O_3 + H_2O = 2NaNO_2 + 2NaOH + N_2O \qquad \ldots \qquad \ldots \quad (1)$$
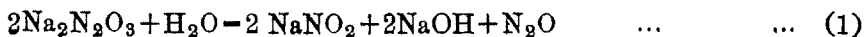
This agrees with the observation of Angeli (*loc. cit.*) who suggested the following equation for aqueous decomposition of hyponitric acid

$$2H_2N_2O_3 = 2HNO_2 + N_2O + H_2O \qquad \dots \qquad \dots \qquad (2)$$
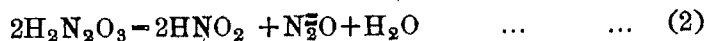
Action of Alkalies.—Previous investigators do not seem to have studied the influence of alkalies on hyponitrates. The rate of decomposition of aqueous solutions of hyponitrates, according to the equation already given, was considerably reduced on addition of $5N$ (approx.) solution of sodium hydroxide. It therefore appears that alkalies have a stabilising influence on hyponitrates; this may be explained by supposing that hyponitric acid being a weak acid, its salts are considerably hydrolysed in solution:

$$Na_2N_2O_3 + 2H_2O = 2NaOH + H_2N_2O_3 \qquad \dots \qquad (3)$$

and the addition of alkali decreases the concentration of the free acid.

Action of Acids.—In presence of dilute acids, hyponitric acid decomposes according to the equation (2), given, above for aqueous solutions; as the concentration of the acid is increased, a greater portion of the salt decomposes according to the equation given by Angeli and Angelico (*loc cit.*)

$$H_2N_2O_3 = H_2O + 2NO \qquad \dots \qquad \dots \qquad (4)$$

Oxidation with Potassium Permanganate.—Oxidation of hyponitrates by means of potassium permanganate in neutral solution was found by Angeli (*Gazzetta*, 1904 34, *i*, 50) to take place nearly quantitatively according to the equation

$$Na_2N_2O_3 + 3O = 2NaNO_3 \qquad \dots \qquad \dots \qquad (5)$$
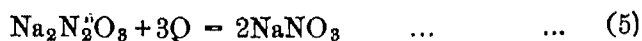
We find that the amount of permanganate required for oxidation depends largely upon experimental conditions. In presence of alkalies and in neutral solutions, a very small amount of permanganate is absorbed. The oxidation of hyponitrate to nitrate is maximum when concentrated sulphuric acid is added fifteen minutes after the permanganate is mixed with the solution of the salt. In other cases, the amount of permanganate required after the addition of acid depends upon the dilution as well as upon the nature of the acid in presence of which the oxidation is carried out. In the case of acetic acid and hydrochloric acid, the amount of permanganate consumed was considerably high probably due to the interaction of these reagents themselves with potassium permanganate. The low values obtained in cartain cases may be attributed to the fact that a portion of the hyponitric acid is simultaneously decomposed according to the equation (2) above.

Reduction.—Previous investigators do not seem to have studied the action of reducing agents on hyponitrates. Among the products of reduction of hyponitric acid, the most likely to be formed are nitrogen, hydroxylamine, hydrazine, and ammonia. By reduction with Devarda's alloy and caustic potash, stannous chloride, sodium hydrosulphite, and zinc and acetic acid, we find that none of the first three are formed, and so far, none of the above reducing agents have been found to effect a quantitative reduction of the hyponitrates.

Thermal Decomposition.—On heating sodium hyponitrate to incipient fusion, Angeli (*loc. cit.*) obtained sodium nitrite and hyponitrite :

$$2Na_2N_2O_3 = 2NaNO_2 + Na_2N_2O_2 \qquad .. \qquad .. \qquad (6)$$

We have further examined the products of this thermal decomposition and found that the reaction cannot be represented by one equation and the hyponitrite formed further decomposes according to the following equation

$$3Na_2N_2O_2 = 2NaNO_2 + 2Na_2O + 2N_2 \qquad ... \qquad (7)$$

EXPERIMENTAL

Preparation of Sodium Hyponitrate.—Pieces of clean, freshly cut sodium metal (5g., weighed under kerosene to avoid possible formation of its oxide) were dissolved by dropping each piece in 15.0 c.c. of methyl alcohol after it was rapidly pressed between folds of filter paper. A solution of hydroxylamine hydrochloride was prepared by dissolving 5.0 g. of the salt, previously dried over calcium chloride, in a minimum quantity of methyl alcohol. The alcohol was thoroughly dried for seven days over calcium oxide and subsequently distilled over metallic sodium, the last and the first distillates being rejected. Each of these solutions was cooled in ice-cold water. They were then slowly mixed, shaken and left for fifteen minutes in a freezing mixture. The precipitate of sodium chloride formed was filtered off. To the clear filtrate were added 25.0 c.c. of a 40% methyl alcoholic solution of methyl nitrate, and the mixture was vigorously shaken and left for four hours in a bath of ice-cold water to ensure the completion of the reaction. A white amorphous precipitate of sodium hyponitrate, which was formed, was filtered on a Gooch crucible, washed several times with methyl alcohol and finally with ether, dried and weighed. (Found : N, 22. 56 ; Na, 37.60. Calc. N, 22. 95 ; Na, 37. 70 per cent).

Potassium Hyponitrate.—Hydroxylamine hydrochloride (7·0 g.) was dissolved in 25.0 c.c. of methyl alcohol. To this was added a solution of 16.8 g. of potassium hydroxide in 25.0 c.c. of methyl alcohol. The details of further procedure are the same as in the case of sodium hyponitrate ·(Found : N, 16.01 ; K,45.11 ; H,11.10. Calc. N,16.28 ; K,45.35 ; H_2O, 10.47 per cent).

TABLE I

Hyponitrates after exposure under differant conditions.

Salt.	Exposed to air for four weeks.		Exposed to air, sat. with aq. vapour, for four weeks.
Na hyponitrate	$NaNO_2$	68·44%	69·00%
	Na_2CO_3	30·67	20·50
	$NaHCO_3$	1 11	9·45
	Nitrate	Traces	Traces.
K hyponitrate	K_2CO_3	11·00	11·54
	KNO_2	34·29	72·55
	KNO_3	54·32	16·00

TABLE II

The rate of decomposition of hyponitrates by cold water (room temp. 30°).

0·05M solution of Na-hyponitrate =10·0 c.c.		0·05M solution of K-hyponitrate =10 0 cc.	
Time.	KMnO₄ soln. (0·1N) absorbed.	Time.	KMnO₄ soln. (0·1N) absorbed.
0	29·6 c.c.	0	18·6 c.c.
4 days.	27·8	1	14·0
7	19·6	2 days.	12 1
10	14·4	4	10·1
13	12·0	5	10·0
15	11·0	6	10·0
18	10·4	7	10·0
21	10·J	10	10·0
24	10·0	13	10 0
28	10·0	15	10 0

TABLE III

Decomposition of No and K hyponitrates by acids.

Salt.	Acid used.	Amount of salt taken.	NO evolved at N. T. P.	N₂ in salt as NO.	N₂ as NO in the salt (average)	N₂ as nitrite in salt.	N₂ as nitrate in salt.	Total N₂ in the salt.	N₂ calc. per formula.
Na₂N₂O₃	HCl	0·0600%	17·77 c.c.	18·51%					
	H₂SO₄	0·0999	29·20	18·27	18·34%	4·57%	0 53%	23·44%	22·95%
	CH₃COOH	0·0820	23·92	18·24					
K₂N₂O₃, H₂O	HCl	0·061	9·78	9·84					
	H₂SO₄	0·0520	⁻8·27	9·94	9·31	2·20	3·90	16·01	16·28
	CH₃COOH	0·0750	11·94	9·95					

TABLE IV

Oxidation with potassium permanganate.

	Na-hyponitrate		K-hyponitrate	
	Equiv. KMnO₄ (0·1N) soln. reqd. by 1·0g of salt.	Equiv. of O₂ reqd.	Equiv. of KMnO₄ (0·1N) reqd. by 1 0 g. of the salt.	Equiv. of O₂ reqd.
No acid was added	344·2 cc.	4·20	241·9 c.c.	4·16
Conc. H₂SO₄ (10·0 c.) immediately after adding KMnO₄ solution ...	436·0	5·32	178 0	3·06
Do added 15 min. after adding KMnO₄ soln. ...	465·4	5 68	241·9	4·16
Nitric acid—Do	416·4	5·08	201·2	3·46
Acetic acid—Do	500·0	6·1	281·4	4·81

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STUDIES ON THE COMPOSITION OF PEPTONE. PART IV.

By Sudhindra Nath Sen

Anhydride and lactam formation or deamination can take place to a certain extent during protein hydrolysis depending on the concentration of hydrochloric acid used. In the analysis of peptone, which generally contains aggregates of a small number of amino-acids, occurence of these side reactions may significantly affect the results. Hydrolysis with $3N$-HCl is found to give best results than acids of other strength.

Determination of the increase in the number of carboxyl groups, amino and imino groups furnishes an experimental means of ascertaining the number of peptide bonds present in a given weight of protein. This increase further shows the number of amino-acids that aggregate together to form the protein molecule. From this average weight of protein containing one mole of peptide bond can be calculated. A protein containing larger amount of lighter amino-acids will have relatively low weight per bond and the reverse will be the case when it contains heavier amino-acids. These results will depend on the characteristics and composition of the protein.

This type of calculation is, however, strictly correct only when the number of peptide bonds is equal to the amino-acids residue obtained after complete hydrolysis. Correction has to be made for the carboxyl group due to amide, but still there remains a source of error due to some side reactions during the process of hydrolysis. Working with a low concentration of hydrochloric acid, anhydride and lactam formations have been observed by various workers with amino-acids and protein hydrolysate (Zelinski and Sadikov, *Biochem. Z.*, 1923, **138**, 156 ; Wilson and Cannan, *J. Biol. Chem.*, 1937, **119**, 309 ; Gavrilov *et al.*, *Bull. soc., Chim.*, 1938, **5**, 442). On the other hand Kossel and Kutscher (*Z. physiol. Chem.*, 1900, **31**, 165) and Hotchkiss (*J. Biol. Chem.*, 1939, **131** 387) observed that deamination of amino-acids takes place to a certain extent in presence of comparatively strong hydrochloric acid at a high temperature. Corrections due to these side reactions are of negligible consequence in case of proteins which contain several hundreds of amino-acids residues, but in case of peptones', which contain aggregates of a few amino-acids, these reactions are of serious consequences in the interpretation of the results.

The following investigation was undertaken with the object of finding up to what extent different acid concentrations affect the results of hydrolysis and of finding out a method of peptone analysis with the least chance of error.

EXPERIMENTAL

Bacto peptone solutions (5%) were made with *6N, 3N* and *N*-hydrochloric acid. Each solution (200 c.c.) was heated with a reflux condenser in an oil bath at 120° to 125° for 10 hours. The hydrolysate (10 c.c.) was taken at different intervals, major portion of HCl in it was removed in vacuum and the volume made up to 10 c.c.

with conductivity water. Carboxyl groups were determined in 2 c.c. hydrolysate by titration with alcoholic potassium hydroxide with thymolphthalein as indicator and values corrected for retained hydrochloric acid by Volhard method using nitric acid as oxidising agent. Increase in carboxyl group was corrected for ammonia (Sen, *Indian J. Med. Res.*, 1942, **30**, 335). The following calculations were made. (*a*) 1 mole of $\overset{\cdot}{C}ONH \equiv 1$ mole of $KOH \equiv 1 \times 10^4$ c.c. of $0.1N$ KOH, or 1 c.c. of $0.1N$ $KOH \equiv 1 \times 10^{-4}$ moles CONH. Hence the increase in COOH (on complete hydrolysis) in multiples of 1 c.c. of $0.1N$-KOH for initial acidity to each c.c. of $0.1N$-KOH gives the moles of peptide bonds present. This is converted into nearest whole number. (*b*) Weight of peptone per mole of peptide linkage was calculated from the weight that would be equivalent to one mole of KOH on complete hydrolysis. (*c*) Average residual weight per peptide bond was calculated by deducting the weight of peptone which is present as free amino-acids (equivalent to initial free COOH groups) from the total weight of peptone containing one mole of peptide bond. Results are recorded in Table I.

<div align="center">TABLE I</div>

Concentration of HCl		Increase in COOH equivalent to c.c. of 0.1N-KOH per 100 mg. peptone at					Number of peptide bonds per protein molecule (average).	Initial free COOH as % of total COOH.	Peptone per mole of peptide.	Average weight per peptide bond.
		1	2	5	7	10				
				hours.						
6N	(a)	4·70	5·76	6.24	6.24	6.24	3	25 0	160.g.	120.0
	(b)	4·80	5·80	6.30	6 30	6.30				
	(c)	4·75	5·78	6.24	6.24	6.26				
	(d)	4·75	5·80	6.26	6.26	6.26				
3N	(a)	4·48	5·88	7.38	7.40	7.39	4	22.0	149.2	116.4
	(b)	4·50	5·88	7.34	7.40	7.40				
	(c)	4·50	5·88	7 84	7.41	7.40				
	(d)	4·55	5·84	7.37	7.38	7.40				
1N	(a)	2·96	4·54	5.62	6.26	6.26	3	24.0	160.0	121.6
	(b)	3·00	4.54	5.68	6.26	6.26				
	(c)	2 96	4.60	5.71	6.30	6.31				
	(d)	2·94	4.54	5.70	6.26	6.31				

Initially 100 mg. of peptone (2.0 c.c. of 5.0% solution) was equivalent to 1.94 c.c. 1N-KOH.

Since in the hydrolysis of peptide bonds carboxyl and amino groups are liberated in equivalent amount, the ratio of these two increases will be constant. In case the peptide linkage contains a proline residue, the breakdown of the bond will liberate an imino group and Van Slyke amino-nitrogen figure will correspondingly diminish. In case there is any anhydride or lactam formation, the amount of COOH will proportionately diminish. At each interval as above, amino-nitrogen was determined by Van Slyke's (gasometric) method after removal of ammonia. Carboxyl groups were converted into amino-nitrogen (1 c.c. of $0.1N$-KOH $\equiv 1.4$ mg. of amino-N). The ratio of these two increases at different intervals is shown in Fig. 1.

Fig. 1.
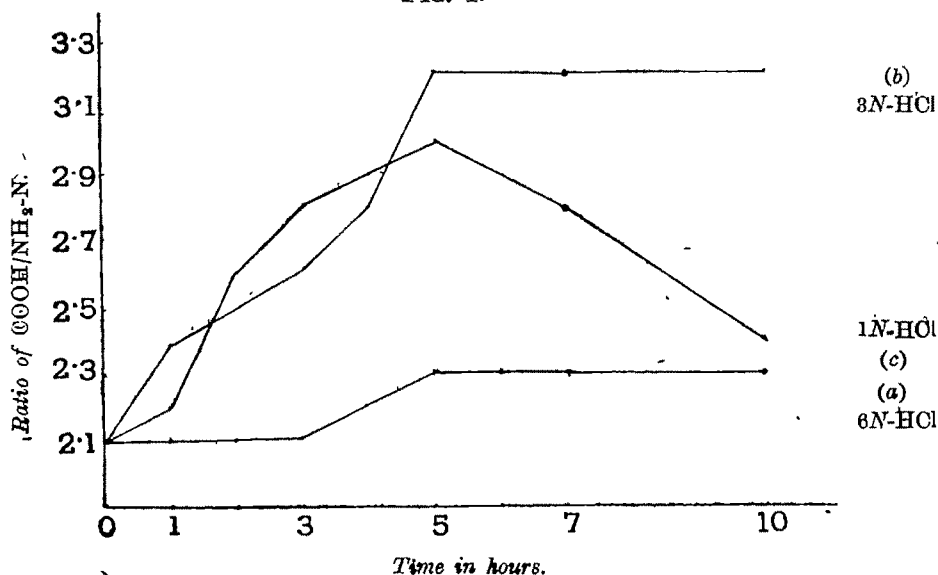
DISCUSSION.

Decrease in the ratio of COOH (in equivalent to amino-nitrogen) and Van Slyke's amino-N has been observed with 1N-HCl after showing an increase for a few hours (Fig. 1.) This decrease may be due either to a decrease in available COOH or to an increase in amino-N. Increase in amino-N out of proportion to COOH groups is not compatible with our present knowledge of protein structure which essentially consists of peptide linkage (Pauling and Niemann, *J. Amer. Chem. Soc.*, 1939, **61**, 1860). The other alternative is unavailability of COOH under experimental condition. If this is due to the combination between α-NH$_2'$ group and COOH group, as in the case of lactam formation with glutamic acid, the ratio would not have altered. But if the combination is between COOH and NH$_2$ group, other than at α position, a decrease in the ratio is apparent. An internal combination in lysine between ϵ-NH$_2$ and COOH groups can take place as observed by Adamson (*J. Chem. Soc.*, 1943. 39). Similar combination between ϵ-NH$_2$ group of lysine and COOH group of other amino-acids is also possible. Side reaction with 1N-HCl takes place after certain time. This is probably due to the decrease in effective acid concentration as the ampholytic concentration increases with hydrolysis. The maximum number of peptide linkage hydrolysed together with a high COOH/NH$_2$-N ratio suggests that with 3N-HCl minimum side reactions take place. Significant difference in the results is also exhibited when other figures are calculated from the data in Table I. Average weight per peptide bond as obtained here is in good agreement with the similar results (115·5) given in literature (Bergmann and Niemann, *J. Biol. Chem.*, 1937, **118**, 301). This average residual weight can be taken to be equal to the weight of hypothetical amino-acid residue but this is true only when the number of peptide linkage is large compared with the number of free terminal COOH groups. On the basis of four peptide linkage per mole of peptone (Table I), weight of amino-acids calculated from average residual weight (116.4+18) and that calculated from average weight per peptide bond $\frac{(116.4 \times 4}{5} + 18)$ exhibits a difference of about 20.0%.

From the figures so far obtained, it appears that best results are obtained with 3N-HCl in case of peptone hydrolysis. Complete hydrolysis takes place within 5 to 6 hours at 120-125°. Further heating for a few hours more does not affect the results.

A STUDY OF ELECTROLYTIC OXIDATION OF CHROMIC SULPHATE TO CHROMATE OR BICHROMATE. PART I. POTENTIOMETRIC STUDY OF ELECTROLYTE

By S. G. Dighe

The nature of the reaction at the anode causing oxidation of trivalent chromium to hexavalent form is studied potentiometrically. Potentials set up on platinum by solutions made up of various combinations of the three reactants CrO_4'', $Cr^{...}$ and $H^.$ ions are measured and the values of E_0, obtained by using the various equations showing the mechanism of reaction, are tabulated. Those obtained by using equation,

$$E = E_0 + \frac{RT}{NF} [ln(Cr_2O_7'') + 14ln(H^.) - 2ln(Cr^{...})]$$ are found to be most constant (average + 1.282 volts).

The commercial regeneration of bichromate of soda from waste blanching liquor from pickling barrels of quaternary alloy coinage blanks having a composition : Silver 50%, Copper 40%, Nickel 5% and Zinc 5% has been worked out and the results reported in a previous paper (Mitter and Dighe, *J. Sci. Ind. Res.*, 1943, **2**, 11).

During the course of that investigation, only points having direct bearing on the commercial regeneration of bichromate were investigated. The importance of understanding the fundamental chemistry and physics of the process, although realised very early, was then not pursued, as the object then was to construct a workable plant for the regeneration of blanching liquor by passing electric current.

Certain peculiarities of the process gradually manifested themselves and it became necessary to study the chemistry of the reaction more closely to obtain an accurate insight into the fundamental changes taking place during the electrolysis.

Regelsberger (*Z. Elektrochem.*, 1900, **6**, 308) was the first to show that the oxidation took place with almost 100% current efficiency on lead anode but did not take place at all on platinum anode.

Le Blanc (*Z. Elektrochem.*, 1901 **7**, 290) obtained 70-90% efficiency at 50° with lead anode. McKee and Leo published the results of their work on commercial regeneration of bichromate from waste chrome liquor (*Ind. Eng. Chem.*, 1920, **12**, 16). However, Müller and Soller (*Z. Elektrochem.*, 1905, **11**, 863) were the first to attempt to elucidate the nature of the reaction. They found that PbO_2 acted catalytically and that the electrochemical action was related to the oxidising properties of PbO_2. The effect of additions of various compounds like KF, Na_2HPO_4 to the electrolyte was found by Schmidt (Dissertation, Charlottenberg, 1909) to be beneficial to the process of oxidation, increasing the efficiency from 82.2 to 93·9% and 98.0% respectively. The most commonly accepted mode of reaction of the electrolytic oxidation of chromium sulphate to chromic acid is represented as follows (*vide* Fajans and Wust, "Practical Physical Chemistry" English, 1920) :—

$$Cr_2(SO_4)_3 + 8H_2O + 6\oplus = 2H_2CrO_4 + 3H_2SO_4 + 6H^. \quad \text{or ionically}$$

$$2Cr^{...} + 8H_2O + 6\oplus = 2CrO_4'' + 16H^. \quad ... \quad ... \quad (I)$$
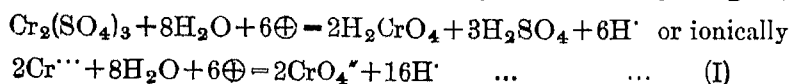
This can be slightly modified (*vide* Sand's "Electrochemistry and Electrochemical Analysis", Vol. III, p. 17),

$$Cr_2(SO_4)_3 + 7H_2O + 6\oplus = H_2Cr_2O_7 + 3H_2SO_4 + 6H^{\cdot}$$
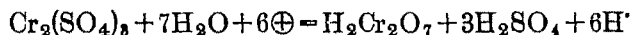
which ionically would be represented as

$$2Cr^{\cdots} + 7H_2O + 6\oplus = Cr_2O_7{''} + 14H^{\cdot} \qquad \ldots \qquad \ldots \qquad (II)$$
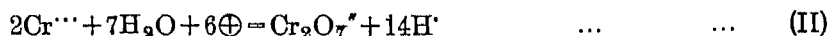
From a comparative study of the generation efficiency of bichromate in alkaline, neutral and acid solutions with platinum anodes, Gross and Hickling (*J. Chem. Soc.*, 1937, 325) suggest that perhaps the electrical energy changes bring about the formation of H_2O_2 thus :

$$2OH' + 2\oplus \rightarrow H_2O_2 \qquad \ldots \qquad \ldots \qquad \ldots \qquad (III)$$

and that the oxidation of chromium sulphate to chromic acid is due to chemical oxidation by H_2O_2.

In view of the above divergent views it was considered essential to study the reaction in details so that the production of bichromate may be easily controlled. The investigation was divided into two parts, (*i*) elucidation of the effect of composition of the solution and (*ii*) elucidation of the effect of the composition of the electrode material.

EXPERIMENTAL

Electrolyte.—To decide among various schemes of reactions suggested by the above workers, potentiometric method was adpted. The potential set up at an electrode depending on the concentration of ions of the reactants and those of the products. If, for example, the reaction runs according to the equation :

$$Cr_2(SO_4)_3 + 8H_2O + 6\oplus \rightarrow 2H_2CrO_4 + 3H_2SO_4 + 6H^{\cdot} \qquad \ldots \qquad (I)$$
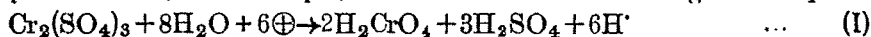
then the E.M.F. set up at an electrode dipped in a solution consisting of these four constituents in equilibrium will be given by the Nernst equation,

$$E = E_0 + \frac{RT}{nF} ln \left\{ \frac{(CrO_4)^{''2} \times (H^{\cdot})^{16}}{(Cr^{\cdots})^2 \times (H_2O)^8} \right\}$$

$$= E_0 + \frac{RT}{nF} \frac{2ln(CrO_4'') + 16\, ln\,(H^{\cdot})}{2ln(Cr^{\cdots}+) \, 8\, ln\,(H_2O)}$$

$$= E_0 + \frac{RT}{nF} \left\{ 2ln(CrO_4'') + 16\, ln\,(H^{\cdot}) - 2ln(Cr^{\cdots}) \right\}$$

where $R = 8.31$ Joules/1°.

$T = $ Absolute temperature $= (273 + 28) = 301°$.

$n = $ Valency of charge $= 6$.

$F = 1$ Faraday of electricity $= 96494$ coulombs.

E_0 is the normal potential of the solution—characteristic of the reaction—being that, which is set up when all the constituents of solution *i.e.*, the reactants and the products have unit activity or have concentration of 1 g. mol. per litre.

$$E = E_0 + 0.00998[2\, log(CrO_4'') + 16log(H^{\cdot}) - 2log(Cr^{\cdots})]$$

$$= E_0 + 0.01[2\, log(CrO_4'') + 16\, log(H^{\cdot}) - 2log(Cr^{\cdots})]$$

Similarly for Sand's equation :

$$E - E_0 + 0.01[\log(\mathrm{Cr_2O_7}'') + 14\log(\mathrm{H}^{\cdot}) - 2\log(\mathrm{Cr}^{\cdots})]$$

According to Gross and Hickling (*J. Chem. Soc.*, 1937, 325) the electrolytic reaction is given by

$$2\mathrm{OH}' + 2\oplus \longrightarrow \mathrm{H_2O_2}^-$$
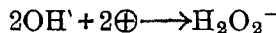
applying the Nernst equation the E.M.F. set up should be given by the equation :

$$E - E_0 + \frac{RT}{nF} \left\{ \; ln \; \frac{(\mathrm{H_2O_2})}{(\mathrm{OH}')^2} \right\}$$

i.e. $E - E_0 + \dfrac{RT}{nF}[-2 \, ln(\mathrm{OH})]$ (Since $\mathrm{H_2O_2}$ decomposes as soon

as formed, being used up for conversion of $\mathrm{Cr_2(SO_4)_3}$ into $\mathrm{H_2CrO_4}$, its concentration at any moment is negligible, *i.e.*, until any $\mathrm{Cr_2(SO_4)_3}$ remains in solution).

$$- E_0 + \frac{0.059}{2} \left[(2\log 10^{-14} - 2\log(\mathrm{H}^{\cdot}) \right]$$

$$- E_0 + \frac{0.059}{2} \left[(2 \times 14 + 2\log(\mathrm{H}^{\cdot}) \right.$$

$$- E_0 + 0.826 + 0.059 \, \log(\mathrm{H}^{\cdot}).$$

Accessories.—Tinsley's vernier potentiometer depending on Poggendorf's compensation method of determining the E.M.F. was used during the course of the investigations.

In the present series of experiments mercurous sulphate—mercury electrode was used as the standard. The bridge connection to the test solution with the standard electrode was made slightly different from the prevailing types. This facilitated renewing the bridge solution $2N\text{-}\mathrm{H_2SO_4}$ (every time a new solution was tested) without much loss of time. This was considered essential as the chromium solution tended to creep up the bridge arms and gave unsteady results.

The E. M. F. of the accumulator was checked against standard cadmium cell before and after each reading with the test solution. The cadmium cell (made in the laboratory) used for this purpose was at intervals checked against standard cadmium cell supplied by Tinsleys.

FIG. 1
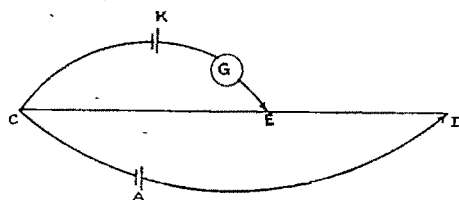
K = cell composed of (*i*) Anode of $\mathrm{CrO_4}''|\mathrm{Cr}^{\cdots}$, (*ii*) cathode of $\mathrm{Hg/Hg_2SO_4}$.   G = galvanometer.
$\mathrm{H}^+|\mathrm{Pt}$
A = accumulator and E = null point showing no deflections.

A platinum electrode dipping into the test solution was a spiral of bright platinum. This electrode and its shape was selected after a few preliminary experiments with (i) bright platinum, (ii) roughened platinum and (iii) platinised platinum and was found the best as it attained stability after a short time. This was used throughout the experiments in the first section of this investigation .

FIG. 2
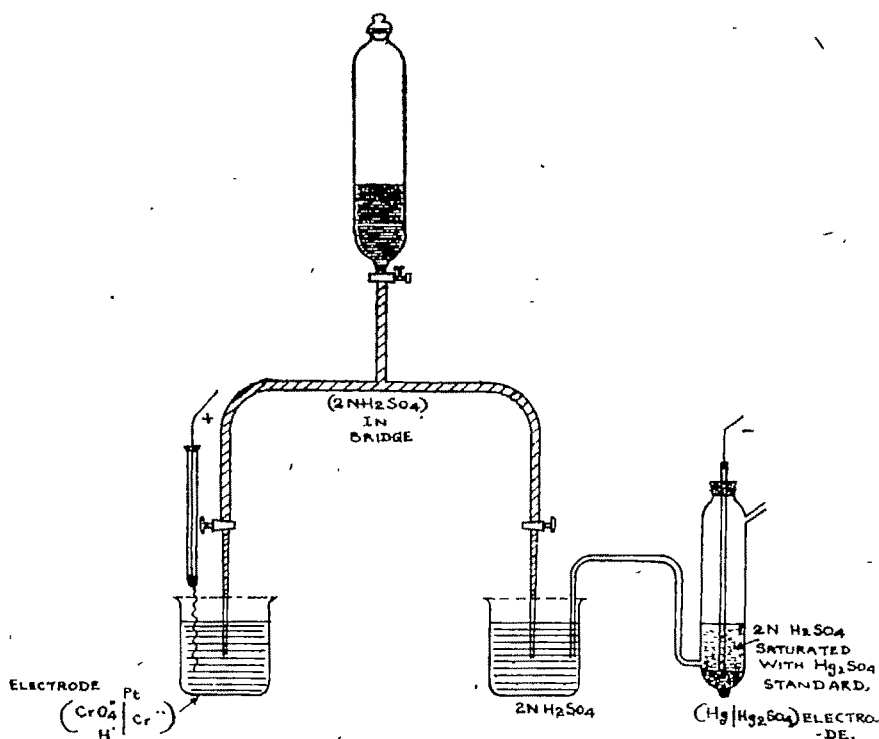
Details of arrangement of cell K (vide Fig. 1)

Air-conditioning of the Apparatus.—An important factor towards getting reproducible results was the constancy of temperature of the whole apparatus, including the accumulator, the test solution, the bridge solution, standard electrode and the standard cell. A thermostat would enable only a few of these accessories to be kept at constant temperature leaving others, like the potentiometer and accumulator at room temperature, which fluctuated widely during the course of experiments.

It was decided therefore to carry out the series of experiments of Section I in an air-conditioned room, kept at a constant temperature of 82°. The effect of this conditioning was at once noticeable in the constancy and reproducibility of E.M.F. of standard cells and accumulator.

Standardisation of Mercurous Sulphate-Mercury Electrode.—Since this electrode *i.e.* mercury—mercurous sulphate—acid sulphuric electrode was used as a standard electrode throughout these investigations, its E.M.F. was determined against

normal calomel electrode. This value was also checked independently against hydrogen electrode. The values agree very well as shown.

	Determined E.M.F.	E.M.F. of calomel against Hydrogen.	E.M.F. of Hg_2SO_4 against H_2.
(a) $Hg \mid Hg_2SO_4 - Hg \mid HgCl$—$+0.3585$			
$+$ $-$ $+0.3583$			
$+0.3588$			
$+0.3585$	$+0.283$	$- +0.6415.$	

Calculated E.M.F. against H_2 electrode $= 0.6415.$

(b) $Hg \mid Hg_2SO_4$ $-Hg \mid H_2$ electrode—$+0.642$
$+$ $-$ normal $+0.643$
$+0.642$

$+0.6423$

E.M.F. directly determined $= +0.6423$

Value of E.M.F. adopted during the investigation $= +0.642$ volts.

The following sixteen solutions were selected for determining their single electrode potentials. The solutions selected for test were made up of chromium sulphate, chromic acid and sulphuric acid and were made up so as to have a total of 0.68 g. mols. of chromium either as $Cr \cdots$ or CrO_4'' in each solution under test. The exact proportions of these were

	I g. mols. per litre	II g. mols. per litre	III g. mols. per litre	IV g. mols. per litre
CrO_4''	0.544	0.408	0.272	0.136
$Cr \cdots$	0 136	0.272	0·408	0·544

thus forming four different proportions of chromium. To each of these mixtures was added sulphuric acid so as to make the concentration of the solution with respect to sulphuric acid 4, 8, 12 and 16% (g./100 c.c.) thus making sixteen solutions. These concentrations of acid sulphuric besides giving ample variations of sulphuric acid for judging the effect of the reagent, also had the advantage that they corresponded with the acid concentrations of the electrolyte at four different stages of the regeneration process in our factory.

Chromic acid of 'Extra Pure' quality (Merck) was used for making a stock solution of chromic acid containing 1.36 g. mols of CrO_4'' per litre, by dissolving 100 g. of CrO_3 and making the solution to 735 c.c.

As chromium sulphate of good quality was not available, chromium sulphate solution was made by reducing 100 g. of the same chromic acid by SO_2 gas and ultimately adding a slight excess of freshly prepared strong solution of sulphurous acid to the hot solution. The complete reduction of chromate ion was

tested by mercurous nitrate solution. To remove any free H_2SO_3 it was evaporated slowly not above 70°. Above this temperature, changes in the constitutional formula of $Cr_2(SO_4)_3$ are likely to occur. The solution was then made to 1470 c.c. The concentration of $Cr^{...}$ ion in this stock solution was 0.68 g. mols. per litre.

A stock solution of acid sulphuric containing 800 g. per litre was made from Baker's 'Analysed' H_2SO_4. This solution of H_2SO_4 was preferred as against concentrated H_2SO_4, as it evolved very little heat when added to a mixture of chromic sulphate and chromic acid, which mixture was prepared about one hour before E.M.F. determination.

TABLE I

Stock solution of $Cr_2(SO_4)_3 = 0.68$ g. mols/litre ; that of $H_2CrO_4 = 1.36$ g. mols/litre, and the stock solution of H_2SO_4 was 80 g./100 c c. or 8 g. mols/litre.

Solution No.	Stock H_2CrO_4 soln.	Stock $Cr_2(SO_4)$ soln.	Stock H_2SO_4 soln.	Total vol.	CrO_4'' conc. per litre.	$Cr^{...}$ conc. per litre.	H_2SO_4 g./100c.c.
1	40 c.c.	20 c.c.	5 c.c.	100 c.c.	0.544 g. mol.	0.136 g. mol.	4
2	40	20	10	100	0 544	0.136	8
3	40	20	15	100	0.544	0.136	12
4	40	20	20	100	0.544	0.136	16
5	30	40	5	100	0.408	0.272	4
6	30	40	10	100	0.408	0·272	8
7	30	40	15	100	0.408	0·272	12
8	30	40	20	100	0.408	0.272	16
9	20	60	5	100	0.272	0.408	4
10	20	60	10	100	0.272	0.408	8
11	20	60	15	100	0.272	0.408	12
12	20	60	20	100	0.272	0.408	16
13	10	80	5	100	0.136	0.544	4
14	10	80	10	100	0.136	0.544	8

TABLE IA

TABLE IB

Solution No.	Mean Pot. against std electrode.	Pot. calc. against Normal hydrogen electrode.	Solution No.	Mean Pot. against std. electrode.	Pot calc. against N-hydrogen electrode.
1	0.600 volt	1.242 volts	5	0.604 volt	1.246 volts
2	0.616	1.258	6	0.605	1.247
3	0.619	1.262	7	0.618	1.250
4	0.630	1.272	8	0.629	1.271

TABLE IC

TABLE ID

9	0.601	1.243	13	0.564	1.206
10	0.603	1.245	14	0.589	1.231
11	0.618	1.260	15*		
12	0.628	1.270	16*		

In Tables IA, IB, IC, and ID are summarised the results of actual experiments carried out with solutions of different composition (These compositions are explained against corresponding numbers of solutions in the preceding table).

TABLE IIA

Values for the expression $\dfrac{RT}{NF}[2ln(CrO_4') - 16ln(H') - 2\,ln\,(Cr^{\cdots})]$

being the concentration correction to E.

(Values according to equation I)

Solution No.	Conc. of CrO_4''	Conc. of $Cr^{\cdots}$	H_2SO_4 (g./100 c.c.)	H' conc. from H_2CrO_4*	H' conc. from H_2SO_4**	Value of $\dfrac{RT}{NF}$ (etc.)
	(g. mols. per litre)					
1	0.544	0.136	4	1.088	0.44	+.041
2	0.544	0.136	8	1.088	0.81	+.056
3	0.544	0.136	12	1.088	1.147	+.067
4	0.544	0.136	16	1.088	1.385	+.075
5	0.408	0.272	4	0.816	0.44	+.019
6	0.408	0.272	8	0.816	0.81	+.037
7	0.408	0.272	12	0.816	1.147	+.050
8	0.408	0.272	16	0.816	1.385	+.058
9	0.272	0.408	4	0.544	0.44	−.005
10	0.272	0.408	8	0.544	0.81	+.017
11	0.272	0.408	12	0.544	1.147	+.033
12	0.272	0.408	16	0.544	1.385	+.042
13	0.136	0.544	4	0.272	0.44	−.036
14	0.136	0.544	8	0.272	0.81	−.006

* For lack of data complete ionisation assumed for simplicity.
** On the basis of actual ionisation data.

TABLE IIB

Values of the expression $\dfrac{RT}{NF}(ln(Cr_2O_7') + 14ln(H') - 2ln(Cr^{\cdots})]$

being the concentration correction to E.

(According to equation II)

Soln. No.	Cr_2O_7'' conc. in g. mols/litre.	$Cr^{\cdots}$ conc. in g. mols/litre.	H_2SO_4 g./100 c.c.	Hydrogen H_2CrO_7*	ion conc. from H_2SO_4**	Value of $\dfrac{RT}{NF}$ (etc.)
1	0.272	0.136	4	0.544	0.44	+0.011
2	0.272	0.136	8	0.544	0.81	+0.028
3	0.272	0.136	12	0.544	1.147	+0.034
4	0.272	0.136	16	0.544	1.385	+0.041
5	0.204	0.272	4	0.408	0.44	+0.015
6	0.204	0.272	8	0.408	0.81	+0.018
7	0.204	0.272	12	0.408	1.147	+0.034
8	0.204	0.272	16	0.408	1.385	+0.041
9	0.136	0.408	4	0.272	0.44	+0.0025
10	0.136	0.408	8	0.272	0.81	+0.009
11	0.136	0.408	12	0.272	1.147	+0.025
12	0.136	0.408	16	0.272	1.385	+0.36
13	0.068	0.544	4	0.186	0.44	−0.04
14	0.068	0.544	8	0.136	0.81	+0.006

* For lack of data complete ionisation assumed for simplicity.
** On the basis of actual ionisation data.

3

TABLE IIc

Corrections of $\frac{RT}{NF}\,[-2\,ln(OH')$ to be applied to E for obtaining E_0 according to equation III derived from Glasstone and Hickling's assumption.

Soln. No.	H·- conc. from H_2CrO_4	H· conc. from H_2SO_4.	Total H· ion conc.	Correction. $(0.826+0.059\ log.\ H·)$
1	0.544	0.44	0.984	0 826
2	0.544	0.81	1.354	0.834
3	0.544	1.147	1.691	0.839
4	0.544	1.385	1.929	0.843
5	0.408	0.44	0.848	0.820
6	0.408	0.81	1.218	0.831
7	0.408	1.147	1.555	0.837
8	0.408	1.385	1.793	0.841
9	0.272	0 44	0.712	0.815
10	0.272	0.81	1.082	0.828
11	0.272	1.147	1.419	0.835
12	0.272	1.385	1.657	0.839
13	0.136	0 44	0.576	0 812
14	0.136	0.81	0.946	0 823

Conc. in g. mols per litre.

TABLE III

Calculated values of E

(On the hydrogen scale.)

Soln. No.	Eqn. I.	Eqn. II.	Eqn.III.	Soln. No.	Eqn. I.	Eqn. II.	Eqn. III.
1	1.200 volts	1.231 volts.	0 416 volt.	8	1.213 volts	1.230 volts	0.430 volt
2	1.202	1.230	0.424	9	1.239	1.241	0 428
3	1.194	1 227	0.422	10	1.228	1 235	0 417
4	1.197	1.231	0.429	11	1.227	1.235	0 425
5	1 227	1.231	0.416	12	1 229	1.233	0.431
6	1.210	1.229	0.416	13	1.242	1.246	0 394
7	1.210	1.226	0.423	14	1.237	1.225	0.408
				Mean	1.212	1.232	0.420

Comparison of the values of E_0 (Table III) as obtained by three equations shows great divergencies between values obtained by equation I and II on the one hand and those obtained by equation III on the other.

A direct determinations of E_0 value by taking equal concentrations of CrO_4'', Cr_2O_7'' and $Cr^{···}$ and unit concentration of H· ions (as detailed in Table IV) were made. Under these conditions of concentration, the expressions $\frac{RT}{NF}$ (etc) in equations I and II reduce to 0 and the value of E obtained equals E_0.

TABLE IV

Direct value of E_0.

Conc of CrO_4'' g. mols/litre.	Conc. of Cr_2O_7'' g. mols/litre.	Conc. of $Cr^{···}$ g. mols/litre.	Total H· conc. g. mols/litre.	Value of E i.e. E_0
0.136	—	0.136	1	1.211
—	0.136	0.136	1	1.216
0.34	—	0 340	1	1.228
—	0.34	0.340	1	1 241
0.408	—	0.408	1	1.218

These values show a great divergence from E_0 value 0.420 calculated by equation III (on the assumption of Gross and Hickling regarding the mechanism of reaction). On the other hand they agree more closely with the values of E_0 calculated by equations I and II and are of the same order. Gross and Hickling

assumptions of the course of electrolytic oxidation seem to have not much justification at least in acid solutions. It is also to be noted that the equation derived from reaction mechanism of these authors does not allow for any change in the value of E with concentration of $Cr^{...}$, Cr_2O_7'' or CrO_4'' ions.

The values of E_0 obtained from equations I and II above (Table III) are reasonably constant and are of the same order of magnitude to those obtained experimentally. Further, the equations also account for the observed facts that the E.M.F. varies with the concentrations of $Cr^{...}$ and CrO_4'' or Cr_2O_7'' and $H^.$. The values obtained from equation I vary slightly more among themselves and from the mean 1.212 volts than those obtained from equation II of which the mean value is 1.232 volts. From these considerations, the mechanism of electrolytic oxidation should be well represented by equation II in which the bichromate and not chromate ions are supposed to be the product of oxidation. It is well known that in the presence of hydrogen ions the balanced reaction

$$2CrO_4'' \underset{-H^.}{\overset{+H^.}{\longleftrightarrow}} Cr_2O_7''$$ is largely shifted towards high concentration of Cr_2O_7'' in preference to CrO_4'' ions. The solutions tested are all highly acidic and it can be assumed that $Cr_2(SO_4)_3$ changes to $H_2Cr_2O_7$.

In the calculation of E_0, the simplifying assumption is made that $Cr^{...}$ in chromium sulphate and CrO_4'' and Cr_2O_7'' in H_2CrO_4 and $H_2Cr_2O_7$ are all completely ionised at dilutions under investigation. This simple assumption cannot hold good particularly for such salt as $Cr_2(SO_4)_3$ which, as is well known, exhibits great tendency towards formation of not easily ionised, hydrated and sulphated complexes.

The chromic acid, analogous to sulphuric acid, is far from being completely ionised. Thus the simplifying assumption made, naturally renders the E_0 value, obtained (i) directly (Table IV) and (ii) those calculated from the measured E.M F. values of solution in which the concentration of $H^.$ ion is not unit and in which CrO_4'' and $Cr^{...}$ are not equal (Table III), slightly different from their true value

Further work is in progress to determine the true extent of ionisation of solutions of $Cr_2(SO_4)_3$ and H_2CrO_4 and H_2SO_4 in presence of all the three dilutions in question, so as to get an idea of $Cr^{...}$, CrO_4'' or Cr_2O_7'' ions present in them.

CONCLUSION

The process of oxidation can therefore be said to be represented by

$$Cr_2(SO_4)_3 + 7H_2O + 6^\oplus \longrightarrow H_2Cr_2O_7 + 3H_2SO_4 + 6H^. \quad \ldots\ldots(II)$$
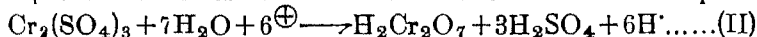
It is not necessary to enunciate a new reaction or equation to bring out the fact that the reaction takes place best in alkaline solution. This is brought out also by equation (II) because in this equation also the higher the $H^.$ ion value, the greater is the tendency to proceed to the left side of equation or reducing. The equation (II) is favoured also by the fact that it allows for change of E with concentration of Cr_2O_7'' and $Cr^{...}$ as found experimentally.

ASSAY DEPARTMENT,
H. M's MINT, BOMBAY.

A STUDY OF ELECTROLYTIC OXIDATION OF CHROMIC SULPHATE TO CHROMATE OR BICHROMATE. PART II.

By S. G. Dighe

Comparison has been made between the potentials set up by the standard solution $Cr_2 SO_4$ (containing CrO_4'' 1.36 g. mol./litre) on electrodes made of the various alloys (Pb, Sb and Ag) with a view to ascertaining the role played by the anode in the process of electrolytic oxidation of chromic sulphate.

The series of experiments detailed in Part I have been carried out using platinum as electrode, which served very well to bring out the relative effects of change in composition of the solution, the electrode remaining constant. The electrode had the advantage of not complicating the process by itself acting chemically on any of the components, as platinum is known to be inert. At any rate, this electrode does not permanently change its chemical composition.

Assuming such an E M.F. or redox potential obtained on platinum to be the standard value, comparison was made between the potential set up by a standard solution on electrodes made of various alloys. This process is likely to bring out the role played by the anode in the process of electrolytic oxidation of chromic sulphate solution.

The standard solution chosen for this purpose was made up of the stock chromium sulphate solution containing 0'68 g. mols. of Cr''' per litre and the chromic acid solution containing 1.36 g. mols. of CrO_4'' per litre and sulphuric acid containing 8 g. mols of H' ion per litre (cf. Part I).

The alloys chosen for making the anode had the following compositions :

Lead + 0.1% silver.
Lead + 3% antimony.
Lead + 3% antimony + 0.1% silver.
Lead + 6% antimony.
ad + 6% antimony + 0.1% silver.

Lead-antimony anodes have been commonly used in accumulators. Addition of a small amount of silver had been found by Dornblatt and Fink (*Trans. Amer. Electrochem. Soc.*, 1941, **79**, 269) to have beneficial effect on the grid alloy for accumulators. Addition of a small percentage of silver to lead was advantageous when used as anodes for electrolysis of sodium chloride (Fink, *ibid.,* 1926, 129). It is also found advantageous in the composition of anodes used for electrolysis of zinc sulphate solutions (Koenig, McEwan and Larsen, *ibid.,* 1941, **79**, 345).

It was therefore considered worthwhile investigating the behaviour of these alloys as anodes for oxidation of chromic sulphate to chromate. The study of these electrodes was two-fold namely determination of

(*i*) Redox potential set up on these electrodes as compared to that on bright platinum and platinised platinum by solutions of

(*a*) $H_2CrO_4 + Cr_2(SO_4)_3 + H SO_4$
(*b*) $Na_2Cr_2O_7 +$ chrome alum $+ H_2SO_4$

(*ii*) The efficiency of generation of chromate from chromic alum on these anodes.

The anodes when chemically untreated gave constantly changing values for redox potential. The anodes were therefore oxidised by keeping them in pickling solution of bichromate and sulphuric acid for a day before taking the potential readings. The readings thus obtained were fairly stable and are given below.

TABLE   I

Redox potential with different electrodes.

(*a*) Test solution made up of :

Propor. by vol. of stock soln.   Ionic comp. of the soln.
H_2CrO_4 $=11.45$ c.c. Cr_2O_7'' $= 0.155$ g. mol./litre.
$Cr_2(SO)_4 =22.85$ $Cr^{...}$ $= 0.310$
H_2SO_4 $=4.25$ $H^.$ $= 1.00$
made up to 50.00 c.c. with water.

Electrode.	Readings of E against Hg/Hg_2SO_4 electrode.	Mean.	E_H (potential against hydrogen).
Bright platinum	$+0.448$ $+0.443$	$+0.448$	1.085
Platinised platinum	$+0.435$ $+0.439$	$+0.437$	1.079
Lead	-0.158 -0.158	-0.158	0.484
Pb+0.1% Ag	-0.045 -0.072	-0.058	0.584
Pb + 3% Sb	-0.138 -0.150	-0.144	0.498
Pb+3%Sb+0.1% Ag	$+0.000$ $+0.009$	$+0.005$	0.647
Pb + 6% Sb	-0.254 -0.254	-0.254	0.388
Pb + 6% Sb+0.1% Ag	-0.103 -0.103	-0.103	0.539

(*b*) Test solution made up of :

Propor. by vol. of stock soln.   Ionic comp. of the test soln.
$Na_2Cr_2O_7$ $=11.85$ c.c. Cr_2O_7'' $= 0.16$ g. mol./litre
$Cr_2(SO_4)$, $\Big\}$ $Cr^{...}$ $= 0.32$
Na_2SO_4, $=23.70$ $H^.$ $= 1.00$
$24H_2O$,
H_2SO_4 $=$ 6.25
made up
   with water$=100.0$ c c.

Electrode.	Readings of E against $Hg/Hg SO_4$ electrode.	Mean.	E (potential against hydrogen), $+$
Bright platinum	$+0.440$ $+0.440$	$+0.440$	1.082
Platinised platinum	$+0.433$ $+0.435$	$+0.434$	1.076
Lead	-0.235 -0.237	-0.236	0.406

Electrode.	Readings of E against Hg/Hg$_3$SO$_4$ electrode.	Mean.	E_H (potential against hydrogen). +
Pb + 0·1 % Ag	− 0 113		
	− 0.121	− 0.117	0.525
	− 0.116		
Pb + 3 % Sb	− 0.177		
	− 0 179	− 0 178	0 464
	− 0.179		
Pb + 3 % Sb + 0·1 % Ag	− 0.029		
	− 0.058	− 0.043	0.599
Pb + 6 % Sb	− 0 236		
	− 0.226	− 0.226	0.416
Pb + 6 % Sb + 0.1 % Ag	− 0.183		
	− 0.143	−0.138	0.504

It appears from the tables that potential set up with all those alloys is much more negative than with bright or platinised platinum. It will also be seen that the addition of silver to each of the alloys increases the redox potential.

For finding out the efficiency of generation of bichromate from chrome alum solution, a solution of chrome alum (sodium) containing 6% available Na$_2$Cr$_2$O$_7$ was used. This sodium chrome alum was made from stock chromium sulphate by adding the calculated quantity of Na$_2$SO$_4$ (anhydrous) and diluting with a strong solution of H$_2$SO$_4$ so that the composition of the solution was Cr$_2$(SO$_4$)$_3$Na$_2$SO$_4$, 6% (as available Na$_2$Cr$_2$O$_7$) and H$_2$SO$_4$, 9.8 g/100 c.c.

The above liquor (45c.c.) was placed as anolyte in a porous pot of negligible resistance to passage of ions and having very low porosity for water and salt molecules. This porous pot was kept in a 350 c.c. beaker which contained 2N-H$_2$SO$_4$ solution in which was dipped a cylindrical lead sheet which formed the cathode.

FIG. 1.

Circuit enclosed above the dotted line is the generating circuit and below it is potentiometer circuit.

AC1 = GENERATING SOURCE

A = AMMETER

V = VOLTMETER.

L = ANODE (OF Pb, PbAg etc)

C = CATHODE IN GEN. CIRCUIT.

T = THERMOSTAT

g = GENERATING CELL

P = POROUS POT

B = BRIDGE

B.S = BRIDGE SOLN

Hg. E. = (MERCUROUS SULPHATE) ELECTRODE

G = NULL POINT GALVANOMETER

P.W = POTENTIOMETER WIRE

AC2 = ACCUMULATOR IN POT. CIRCUIT.

TH. R. = THERMO REGULATOR.
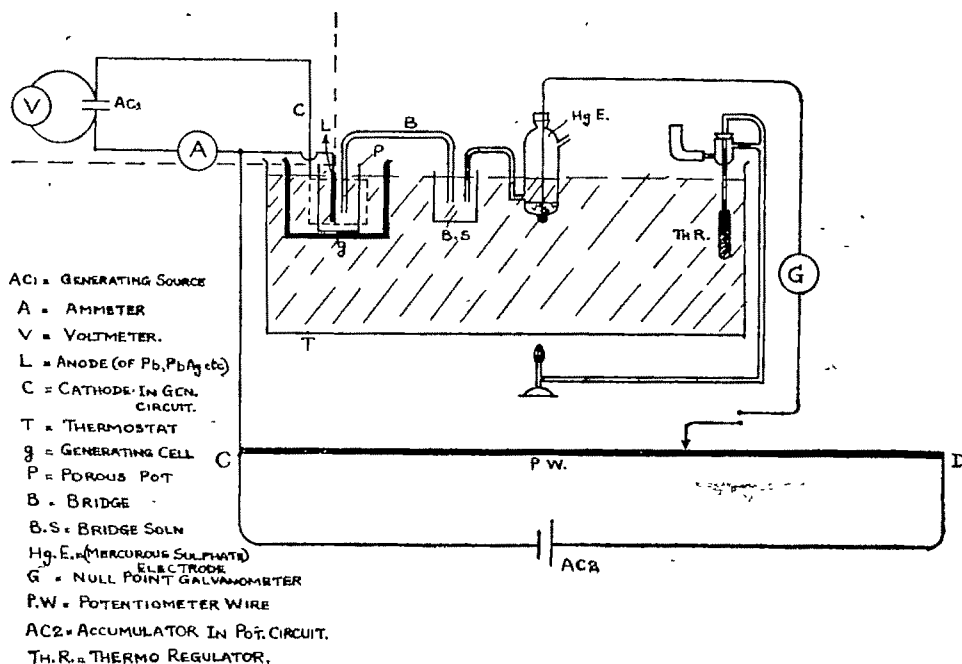
In the porous pot were immersed the anode rods to be tested, taking care that in each case the same area of anode was immersed, keeping the current density constant, as the same current was passed every time through the solution. The C.D. of 17.5 amps. per sq. ft. was kept. The voltage developed was noted as also the single electrode potential at the anode.

The determinations of the latter were made against Hg/Hg_2SO_4 electrode using $2N$-H_2SO_4 bridge as equipment as-in section I.

The electrodes were prepared from virgin metals in a vertical cylindrical mould and were used without any mechanical treatment of the surface, but they were chemically treated. As it is known that the unoxidised surface gives continuously changing readings of voltage, it was thought better to oxidise the surface of the anodes by keeping them in a strong solution of $Na_2Cr_2O_7 - H_2SO_4$ mixture for a few days prior to use.

One hour before use they were oxidised electrolytically at the anode in a bichromate solution and after rinsing in water they were in each case immediately used in generation experiments. This pickling process ensures uniformity of oxide coating and is likely not to consume any portion of current in oxidising the surface to the detriment of the solution. The results must therefore be assumed to be free from all disturbing effects and differences in the behaviour must be assumed to be due to inherent differences in their composition. The recording voltmeter correct to 0.01 volt and ammeter reading upto 0.005 amp. were used. These readings were taken every hour and the experiment was over after the fourth reading during which period about 70% of available bichromate were generated. The generating beaker and the Hg_2SO_4 half cell were kept in a thermostat at 95°F. The thermo-regulator had a sensitiveness of ±0.5°F.

TABLE II

	Electrode-Pb				Electrode-Pb+1%Ag.			
Period in hours from start of generation.								
	1	2	3	4	1	2	3	4
Bichromate generation (in g.)	0 702	1.368	1,832	1.922	0 718	1,078	1.406	1.646
Voltage	2.90	2 95	2.95	2.95	2.95	2.87	2.99	2.88
Amperage.	0.415	0 40	0.425	0.425	0 425	0.392	0.395	0 415
% Current efficiency.	93.6	89 5	80.7	63 4	92.05	71 92	63.02	55.18
S. E. potential	1.363	1.377	1.404	1.418	1.315	1.329	1.365	1.316
	Electrode-Pb+3 % Sb.				Electrode-Pb+3% Sb+0.1%Ag.			
Bichromate generation (in g)	0 711	1.399	1.673	1,996	0.375	1,420	1.770	1,920
Voltage	2.92	2.96	2.94	2.95	2.80	2 80	2.81	2.84
Amperage	0 40	0.39	0.40	0.40	0,40	0.385	0.415	0.385
% Current efficiency	96.7	89.0	76.3	80.0	51.1	98.6	80.1	66 1
S. E. potential	1 338	1.411	1.416	1.423	1.233	1 288	1.327	1.380
	Electrode-Pb+6%Sb.				Electrode-Pb%+6%Sb+ 0·1% Ag.			
Bichromate generation (in g.)	0.780	1.345	1.675	1.891	0.826	1.221	1.693	1.677
Voltage	2.88	2 94	2.92	2.94	3.00	2.89	2.94	2.94
Amperage	0.40	0.40	0.415	0.425	0,47	0.35	0.40	0.42
% Current efficiency	99.5	91 62	75.01	62.8	96.0	81.2	75.0	58.6
S. E. potential	1.334	1 381	1.405	1.417	1.379	1.365		1.344

Summary of, results.

Anode.	During generation of bichromate. Average voltage		Redox potential.	Over-voltage.	Current efficiency.
	Terminal.	Anodic.			
Pb	2.95	2.032	0.406 volts	1.626 volts	63%
Pb+3% Sb	2.94	2.039	0.464	1.575	68
Pb+6% Sb	2.92	2.026	0.416	16.12	63
Pb+0.1% Ag	2.93	1.978	0.525	1.448	55
Pb+0.1% Ag+ 3% Sb	2.81	1.949	0.599	1 350	66
Pb+0.1% Ag+ 6% Sb	2.94	2.005	0.501	1 501	58·

From curves in Fig. 2, it would be seen that the alloys can be classified into two groups as .

Group I.	Group II,
Pb	Pb+0.1% Ag.
Pb+3% Sb.	Pb+3% Sb+0.1% Ag.
Pb+6% Sb.	Pb+6% Sb+0.1% Ag.

Curves I and II show redox potential. Curves III and IV show anode potentials determined during bichromate generation experiments with each of these alloys as anode. These values are higher than the corresponding values in curves I & II. The difference must be due to oxygen overvoltage at these electrodes. For better comparison, values of efficiency of oxidation have been plotted on the same graph. (*cf.* Curves V and VI).

FIG. 2.
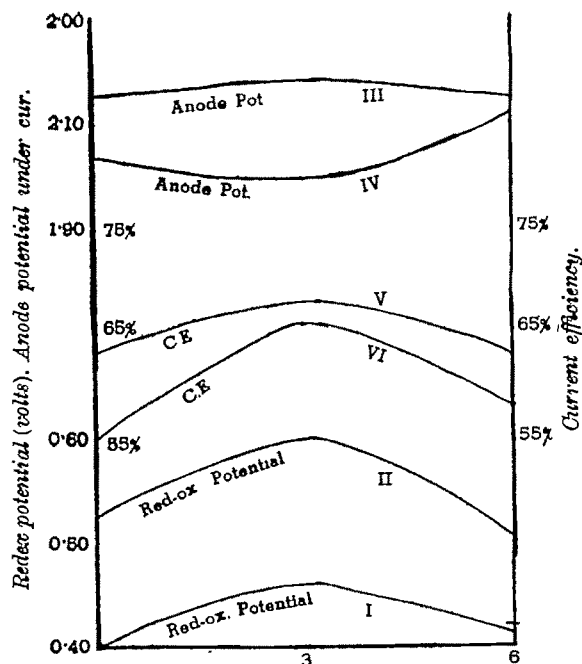
% of Sb in anode-alloy
Curves I, III & V refer to Pb-alloy and the
rest to Pb + Ag alloy

FIG. 3.
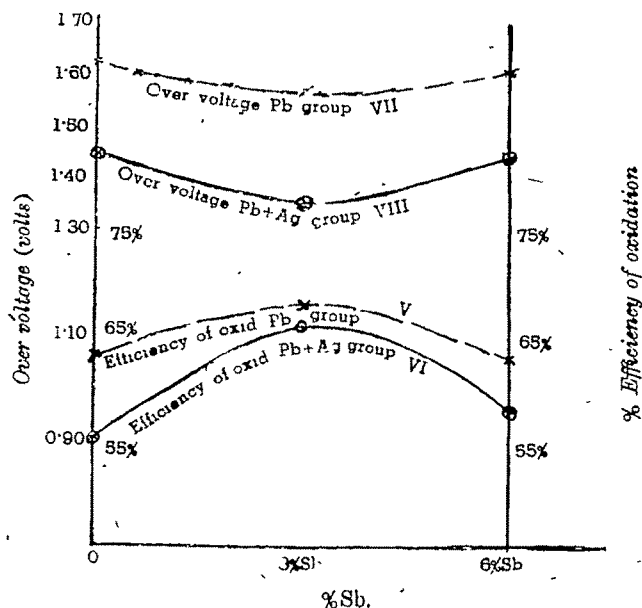
The curves show that the investigated properties of alloys are not a near function of the antimony content of the alloy, 3% antimony content of the alloy being a turning point in the properties studied above.

Effect of addition of 0 1% Ag to Pb or Pb-Sb has been (*i*) to increase the redox value; (*ii*) to decrease the overvoltage, (*iii*) to decrease the current efficiency.

It seems (*cf.* Fig 3) that for a particular group of alloys the smaller the overvoltage, the greater the efficiency of generation of bichromate. We see independent confirmation of this in the case of platinum anodes, the data for which are given below.

	Redox Pot.[*]	Oxygen overvoltage.[**]	Current efficiency[***]
Bright platinum	1.08 volts	1.47 volts	1%
Platinised platinum.	1.08	0.86	97

It is significant that bright platinum having almost the same redox potential value as but a higher overvoltage than that of platinised platinum.

Thus, these two anodes, which are chemically identical and have almost the same redox potential, offer convincing support for the conclusion drawn' from the anodes of Pb, Ag and Sb that within a particular group of anodes the current efficiency is higher when the overvoltage is lower.

[*] Redox potential values are from author s data.
[**] Oxygen overvoltage figures from International tables (McGraw Hill).
[***] C. E figures are those of Gross and Hickling (*J. Chem. Soc.*, 1937, 825).

4

This conclusion seems to be in opposition to the generally accepted principle "that higher overvoltage conduces to higher efficiency of oxidation". This apparent contradiction, however, gives us an insight into the part played by the anode. The above accepted principle would be true for insoluble anodes where the equilibrium is set up between the two opposing tendencies of the reaction in solution, *via* the electrode, which acts as a conductor and takes no part in the chemical reaction. Thus, the E.M.F. set up on an insoluble electrode is a function of the energy change in solution only.

The lead alloy electrodes on the other hand do not seem to be truly insoluble. This is borne out by the fact that while redox potential is quickly set up on bright platinum, which is insoluble, the redox potential in the case of lead alloy electrode attains a steady value only after a lapse of some hours. The E.M.F. set up on electrodes of lead alloys seems to be a resultant of the energy change due to the normal reaction in solution and the energy change due to reactions between the electrodes and the solutions.

It is significant that redox potential on platinised platinum which is chemically identical with bright platinum is also +1.08 volts. The redox potential value, therefore, seems to be governed by the chemical nature of the anodes; whereas, the overvoltage values, as generally accepted, are determined to a large extent by the physical nature of the surface, as is evidenced by the large difference of overvoltage shown by bright platinum and platinised platinum.

Thanks are due to Colonel Sir A. J. Ransford, C.I.E., Mint Master, Bombay, for his encouragement and interest in the investigations and for permission to publish the results

Thanks are also due to Mr. G. C. Mitter, O.B.E., M. Sc., F. R. I.C., Chief Assayer, His Majesty's Mint, Bombay for his interest in the work and for making valuable suggestions.

CHEMICAL EXAMINATION OF THE SEEDS OF *WRIGHTIA TINCTORIA.*
CHEMICAL EXAMINATION OF THE FIXED OIL

By Dharam Bal Parihar and Sikhibhushan Dutt

The oil from the seeds of *Wrightia Tinctoria* has been examined and its constituents found out.

Wrightia Tinctoria or Indrajav or Mitha Indrajav, as it is known in Bengali and Hindi respectively, is a small deciduous tree belonging to the natural order of *Apocynaceae*. It is indigenous to Rajputana, Central Provinces, Deccan, Konkan, S. M. Country, Ceylon and Burma and has been found to grow wild in tremendous profusion on the Western Ghats of Madras Presidency. The plant has been described by Kirtikar and Basu ("Indian Medicinal Plants", Part II, p. 1581) and also by K. M. Nadkarni ("Indian Materia Medica", p. 905). The plant, especially the bark and the seeds are regarded as highly medicinal in curing a variety of ailments. The bark and the seeds have been found to be equally effective and contain the same therapeutic properties as those of *Hollarrhena antidysentrica*. The general appearance of the seeds is such as to make their detection very difficult if mixed with the seeds of *Hollarrhena antidysentrica*. The seeds are used as an aphrodisiac and as a tonic they are given in seminal weakness.

The fixed oil from the seeds of the plant does not appear to have been previously examined although the fixed oil from a similar species of Wrightia, namely *Wrightia anamensis* has been examined by Margaillen (*Compt. rend.*, 1931, 192, 373) with entirely different results. The chief fatty acid of this latter fixed oil has been described by the author as hydroxy-oleic acid, whereas in the present investigation the chief constituents have been found to be oleic and linolic acids. On pressing the seeds in the ghani, the oil was obtained in a yield of 30. 49% as a deep red, highly viscous liquid. The oil has been worked up in details and its constituents have been descibed in the experimental portion of the paper.

Experimental

A sample of the seeds when burnt in a porcelain dish left on ignition 4.32% of a greyish white ash, consisting of 73.21% of water-soluble and 26.79% of water-insoluble inorganic material. The ash contained Ca, Fe, Na, K (traces), silica, chloride, sulphate, carbonate and phosphate.

Extraction of the Fixed Oil.—5' 2 Kilos of the seed when pressed in a mill gave 1.585 Kilos of the oil in a yield of 30'49%. The crude oil, which had a deep red colour, was digested with animal charcoal and Fuller's earth and filtered hot. The oil after purification was a deep red, highly viscous, thick liquid, and possessed a characteristic odour of the drug. Even on prolonged standing no sediment or crystalline matter was deposited from the oil.

Examination of the Oil.—The oil does not contain any nitrogen or sulphur. It burns with a semi-sooty and odourless flame. In order to test the drying power

of the oil, a few drops of it were spread on a clean glass plate and kept at room temperature. After a fortnight the oil became very sticky proving it to be of the class of semi-drying oils. The physical and chemical constants of the oil are given in Table I.

TABLE I

Specific gravity (24°)	0.9552	Acetyl value	11.26
Refractive index (24°)	1.4940	Acid value	4.31
Viscosity (20°)	4.134	Riechert Missel value	0 81
Saponification value	180 1	Hehner value	92 6
Iodine value	87.6	Unsaponifiable matter	1.42%

The oil (200 g.) was then saponified with alcoholic potash as usual, the excess of alcohol distilled off and the soap dissolved in water, repeatedly extracted with ether in order to remove the unsaponifiable matter. The soap solution after the removal of the unsaponifiable matter decomposed with dilute sulphuric acid in presence of petrol-ether The petroleu n ether fatty acid layer was washed free from traces of sulphuric acid by water in a separating funnel, the solution dried (calcium chloride) and the solvent distilled off from a water-bath. The last traces of petroleum ether were removed from the mixed fatty acids thus obtained by heating on the water-bath and passing a current of carbon dioxide. Table II gives the constants of the mixed fatty acids.

TABLE II

Consistency	Semi solid
Neutralisation value	191.4
Mean mol. weight	293.1
Sp. gr. (64°)	0.8976
Iodine value	92.1

The mixed fatty acids (150 g.) were separated into saturated and unsaturated portions by Twitchell's modified lead salt-alcohol method (*Ind. Eng. Chem.*, 1921, **13**, 806). Table III gives the percentages, iodine values and mean molecular weights of the saturated and unsaturated fatty acids.

TABLE III

Acid.	% in mixed acids.	% in oil.	I. V.	Mean M. W.
Saturated	32.8	30.37	0.95	285.6
Unsaturated	67.2	62.23	134.7	281.4

Examination of the Unsaturated Acids.—The acids were treated with bromine according to the method of Jamieson and Baughmann (*J. Amer. Chem. Soc.*, 1920, **42**, 1198). Weighed amount (about 5 g.) of the liquid acids was dissolved in 100 c.c. of dry ether, the mixture was cooled in a freezing mixture to -10° and dry ethereal bromine was added drop by drop till it was in excess The

temperature of the mixture was not allowed to rise above -5° during the addition of bromine. Then the mixture was allowed to stand for 2 hours at -10°, during this time no crystalline matter settled. Thus the absence of linolenic acid was confirmed. The ethereal liquid was then freed from excess of bromine with an aqueous solution of sodium thiosulphate in a separating funnel. The solution was then dried (calcium chloride), filtered and the ether distilled off. The residue was dissolved in petrol ether (b. p. 40-60°) and cooled in a refrigerator when cubical crystals of linolic tetrabromide (m. p. 112°) separated out from the solution showing the presence of linolic acid. The filtrate was evaporated to dryness and the bromine content estimated. Table IV gives the results of analysis.

TABLE IV

Weight of the unsaturated acids taken ...	...	4 8592 g.
Weight of linolic tetrabromide insoluble in petrol ether	...	2.7212
Weight of residue (dibromide and tetrabromide)	...	6.2413
Bromine content of the residue	...	41.23%
Weight of tetrabromolinolic acid in the residue	..	2.3749 g.
Weight of total tetrabromolinolic acid ...	...	5 0961
Weight of oleic-dibromide in the residue ...	...	3.8664
Weight of linolic acid equivalent to tetrabromide	...	2.3781
Weight of oleic acid equivalent to dibromide	...	2 467

The percentage of oleic acid and linolic acid in the unsaturated acids, total fatty acids and in the original oil are given in Table V.

TABLE V

Acid	Percentage in unsaturated acids.	Percentage in total fatty acids.	Percentage in original oil.
Linolic	48 94	34.88	30.46
Oleic	51.06	34.32	31.77

Examination of the Saturated Fatty Acids.—The saturated fatty acids obtained by the lead salt-alcohol method were freed from traces of liquid fatty acids by pressing on a porous plate. The acids thus obtained were almost colourless and melted between 60° and 69°. For the purpose of separation, the mixed acids were converted into their methyl esters by taking 40.2 g. of the saturated acids in a round bottomed flask, adding 170 g. of Merck's extra pure methyl alcohol and about 7g. of concentrated sulphuric acid, and the mixture was refluxed for about 4 hours on a water-bath. The excess of alcohol was then distilled off, the residue poured into about five times its volume of cold water, the liquid neutralised with sodium carbonate and the ester extracted with ether. The ethereal extract was washed first with distilled water, then with saturated solution of calcium chloride to remove any alcohol and finally with water. The ester was dried over anhydrous sodium sulphate and ether removed by distillation. The esters (41.7 g), thus obtained, were then fractionated under reduced pressure. The saponification values of each fraction were determined and the mean molecular weight calculated. Table VI gives the results.

TABLE VI

Fraction No.	Boiling range Pressure 11 mm.	Wt. of distillate.	Sap. value.	Mean M. W. from Sap value.		Percentage of acids Myristic.	Palmitic.	Stearic.	Arachidic.
				Esters	Acids				
1	160°-170°	2.7402 g.	208.7	268.7	254.7	4.06%	95.04%	...	...
2	170°-180°	11.2050	202.2	277.4	263.4	...	71 1	28.9%	...
3	180°-195°	18.0432	189.0	296.8	282.8	...	3 9	96 1	...
4	above 195°	9 6714	175 5	319.6	305.6	...	...	21.1	78.9%

The various fractions of the esters were separately hydrolysed with alcoholic caustic potash and the liberated acids repeatedly crystallised from alcohol. Palmitic, stearic and arachidic acids were thus obtained in almost pure condition and identified. The results are given in Table VII.

TABLE VII

Fraction No.	M. p. of acid isolated.	Conclusion.
1	58-59°	Almost all palmitic acid
2	63.5-64.5°	Palmitic and stearic acid
3	68-69°	Practically all stearic with traces of palmitic acid.
4	74.5-75.5°	Mostly arachidic with traces of stearic acid.

Table VIII gives the composition of saturated fatty acids.

TABLE VIII

Acids.	Percentage in mixed saturated acids.	Percentage in total mixed fatty acids.	Percentage in oil.
Myristic	0.23	0.08	0.07
Palmitic	27.18	8.90	8.24
Stearic	54.29	17.80	16.48
Arachidic	18 35	6.03	5 58

Examination of the Unsaponifiable Matter.—The unsaponifiable matter obtained by ether extraction of the soap solution was washed repeatedly with water and the solvent distilled off. The substance crystallised in yellowish white crystals. On repeated crystallisation of the compound from alcohol it was obtained in fine colourless silky needles and flakes (m. p. 134.5°). The acetyl derivative melted at 125°. It is evidently sitosterol.

The seeds of *Wrightia tinctoria* have thus been found to contain 30.49% of a deep red semi-drying fixed oil, which contains the following constituents.

Glyceride of Linolic acid		31.82 %
,,	Oleic acid	33.98
,,	Myristic acid	0.07
,,	Palmitic acid	8.65
,,	Stearic acid	18.24
,,	Arachidic acid	5.82
,,	Unsaponitiable matter (mainly sitosterol)	1.42

SYNTHESIS OF DIHYDROXYTARTRONIC ACID

By (late) K. C. Ghose

A synthesis of dihydroxytartaonic acid has been described

As a preliminary to the synthesis of ascorbic acid (I), the dihydroxytartronic acid (II) has been synthesised according to the method described below.

$$
\begin{array}{cc}
\text{(I)} & \text{(II)}
\end{array}
$$
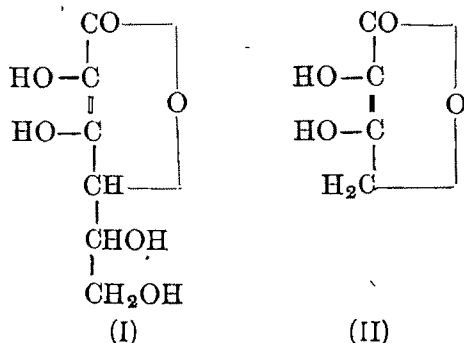
Magnesio-(or better the sodio) salt of acetoxymalonic ester in benzene is reacted in the cold with chloroacetyl chloride; the resulting condensation product, chloroacetyl-acetoxymalonic ester on hydrolysis under specific conditions yields the lactone (II), m.p. 153° (decomp.) (literature 153°, Michael and Jung, *Ber.*, 1933, **66**, 1291).

.Further investigations in this line are in progress.

Experimental

Ethyl Acetoxymalonate.—Ethyl bromomalonate (45 g.) was reacted with freshly fused potassium acetate (22 g.) under glacial acetic acid by refluxing gently in an oil-bath for 4 hours. The reaction product was treated with excess of cold water and worked up according to the usual procedure, yield 31 g.

The use of sodium acetate in place of potassium acetate resulted in very poor yield.

Ethyl Chloroacetylacetoxymalonate.—(a) The magnesio-salt of ethyl acetoxymalonate was condensed with chloroacetyl chloride according to the following method (*cf.* Lund, *Ber.*, 1934, **67** 935).

Ethyl acetoxymalonate (11 g.), magnesium (1.2 g.), alcohol (5 c.c.) and a few drops of carbon tetrachloride were taken in a flask fitted with a condenser and guard tubes and refluxed on a water-bath. When the reaction started, a mixture of ethyl acetoxymalonate (11 g.) and alcohol (8 c.c.) was dropped from a dropping funel and the refluxing was continued till the whole of magnesium went into solution. The flask was then cooled, 50 c.c. of dry ether were added and then a mixture of 15 g.

of chloroacetyl chloride and 20 c.c. of ether dropped. The reaction mixture was then refluxed on a water-bath for 2 hours. On cooling it was treated with excess of cold water containing a little sulphuric acid, extracted with ether, ether removed and distilled. The fraction boiling at 145-50°/10 mm. was collected, yield 10 g. (Found : C, 44. 7 ; H, 5.07 ; Cl, 11.8. $C_{11}H_{15}O_7Cl$ requires C, 44.8 ; 5.09 ; Cl, 12.1 per cent).

(b) Ethyl acetoxymalonate (6.1g.) was dropped slowly on molecularised sodium (0.8 g.) under benzene in a flask cooled in ice and the flask was kept overnight when all the sodium went into solution. The sodio-salt of ethyl acetoxymalonate in benzene was next dropped on 5 g. of chloroacetyl chloride in the cold and the reaction mixture after 5-6 hours was refluxed for 2-3 hours on a water-bath and then worked up as usual and distilled, the fraction boiling at 145-50°/10 mm. being collected, yield 5 g.

Dihydroxytartronic Acid (II).—The hydrolysis of ethyl chloroacetylacetoxy-malonate to dihydroxytartronic acid was repeatedly attempted according to the method of Anschütz and Bertram (*Ber.,* 1903, **36**, 471), but all efforts proved to be unsuccessful, Finally, it was hydrolysed as follows :

Sodium (1.6 g.) was dissolved in methyl alcohol (25 c c), 1.5 c.c. of water (calcula-ted to form sodium hydroxide with sodium) was added and nitrogen was bubbled through the mixture. After some time, when the air had been replaced by nitrogen, 5 g. of the condensation product were added and the reaction mixture was refluxed in an atmosphere of nitrogen for 2 hours. Salts, which separated on cooling, were filtered, washed with methyl alcohol and dissolved in water freed from air by boiling and cooling in an atmosphere of nitrogen. The solution was cooled and acidified with dilute sulphuric acid and kept overnight in nitrogen atmosphere. The solution was saturated with ammonium sulphate and repeatedly (10 times) extracted with ethyl acetate. Ethyl acetate was removed and the residue kept in a vacuum desiccator, when clusters of needle-shaped crystals were obtained which on recrystallisation from ether melted at 153° (decomp.). (Found ; C, 41.2 ; H, 3.45. Calc. for $C_4H_4O_4$: C, 41.4 ; H, 3.45 per cent).

The use of water in excess of the calculated amount resulted in the failure of the reaction.

Thanks of the author are due to Prof. P. C. Mitter and Prof. S. N. Bose for their kind interest and Dr. D. K. Banerjee and Dr. N. C. Ganguly for helpful suggestions The author is also indebted to Mr. N. N. Ghosh for the microanalysis of one of the compounds.

ON THE ACTIVATION OF PAPAIN

By N. Ray

The rate of activation of papain by sodium thiosulphate has been further increased by incorporation of 8-hydroxyquinoline.

Papain is one of the common proteolytic enzymes used in the general hydrolysis of protein substances. As available in the market, it is not so active and accordingly, its proteolytic activity is generally enhanced by incorporation of some reducing substances. In the breakdown of animal protein, like muscle tissue, the glutathion or the cystine molecule present in the substrate often behaves as an activator (cf. Gottschall, *Food Research*, 1944, **9**, 6). Brewer (*J. Bact.*, 1943, **46**, 395) has used sodium sulphide in preparing a bacteriological medium for a papain-protein digest. Recently Basu et al (*Ind. Med. Gax.*, 1945, **80**, 398) have activated papain by sodium thiosulphate in preparing culture medium from ground nut. Even activation does not increase the proteolytic activity to the degree that may be obtained by using trypsin. In connection with certain other investigations that are being followed in this laboratory, enhancement of the rate as well as the degree of digestion of protein bodies by papain are highly desirable. As such a work was undertaken to find a clue to its proteolytic activity and the factors on which the latter may depend.

Various hypotheses are being put forward (cf. Willstätter, Kuhn and Sobotka, *Z. physiol. Chem.*, 1924, **138**, 184 ; Waldschmidt-Leitz et al, *ibid.*, 1933, **214**, 75 ; Ganapati and Sastri, *Biochem J.*, 1939, **33**, 1175 ; Giri and Seshagirirao, *Science & Culture*, 1942, **7**, 408) from time to time for the factors that are responsible for the proteolytic activity of commercial papain. Anson (*J. Biol. Chem.*, 1940, **135**, 797) finds that heavy metal impurities catalyse the oxidation of protein-SH group, as present in papain, by oxygen or an oxidisable matter. Iron and/or copper may also act as an oxidase catalyst (cf. also Hofstede, *Quart. J. Pharm. & Pharmacol.*, 1930, **3**, 103). The influence of a reducing agent in restoring or enhancing the activity of papain may be due to the conversion of the oxidised complex as present in the enzyme. Copper, which is again known to lower this enzymatic activity, may exert its characteristic action by catalysing the oxidation of ferrous ion to the ferric state. On this hypothesis the activity of papain may be further increased by incorporating a suitable reagent capable of removing the iron oxidase during the enzymatic fission. A reagent like this is found in 8-hydroxy-quinoline which is known to react with iron salts to form insoluble compounds and thereby may remove them from the phase of enzymic action. This may further potentiate any di-enol oxidation-reduction group if present in the enzyme (cf. Giri and Seshagirirao, *loc. cit* ; and Lyman, Schultze and King, *J. Biol. Chem.*, 1937, **116**, 563). This expectation has been fully realised and the data cellected in the course of these investigations are being recorded in this paper.

E X P E R I M E N T A L

Substrate.—Casein (commercial variety) of known composition was taken in 500 c. c. distilled, water and heated for ½ hour on a boiling water-bath. This was then mixed with a few c. c. of $2N$- sodium hydroxide solution to afford an almost uniform solution and heated further for ½ hour. This resulted in a milky solution of pH 5.0.

Enzyme.—Papain (Ceylon variety, 2.4 g.) was taken in 25 c. c. water and mixed with 25 c. c. of a 4.8% solution of sodium thiosulphate (chemically pure). The whole was then left aside at room temperature (28°) for about 1 hour.

In another flask a similar mixture was further incorporated with an alcoholic solution (5 c. c.) of 8-hydroxyquinoline (4.8%).

Digestion.—This was carried with the casein substrate at 50° in an incubator. The substrate was taken separately in four different 100 c. c. flasks, and treated with the enzyme preparations.

(*a*) Papain alone ; (*b*) papain mixed with sodium thiosulphate as mentioned above ; (*c*) the enzyme solution containing papain-sodium thiosulphate-8-hydroxyquinoline ; and (*d*) a fresh alcoholic extract of pancreas. The proportion of the enzyme to the protein (casein) was always 1 : 25, and the final volume of the digestion mixture was so adjusted that the concentration of the substrate (casein) remained about 10%.

The flasks were then placed in the incubator and were shaken occasionally. The rate of digestion was followed up to 48 hours. From time to time 2 c. c. of the suspension were taken out, boiled, cooled, and filtered. The clear filtrate was titrated against $0.1N$-alcoholic potassium hydroxide solution in presence of excess of alcohol using thymolphthalein as indicator (*cf.* Willstätter and Waldschmidt-Leitz., *Ber.*, 1921, 54, 2988). The results are recorded below.

TABLE I

Figures indicate the number of c. c. of $0.1 N$-KOH per 2 c. c. of the digest.

Period of digestion.	Papain alone (control)	Enzyme Activated with thio.	Papain Activated with thio and oxyquinoline.	Enzyme Trypsin (Alcoholic solution)
2 hours.	0.8	1.5	2.44	2.6
4	1.2	1.9	2.21	3·1
6	1·5	2.3	...	3·6
8	1.7	2.5	...	3,8
24	2.6	3.1	4.37	4,4
28	2.7	3.1	4.37	4,4
30	2.7	3,15	...	4,5
46	...	...	4,56	...
48	3.2	3,30	4.68	4.7

From the figures in Table I it is evident that the amount of liberated carboxyl group, as measured by using the Willstätter technique from the protein casein under the influence of the enzyme papain at varying conditions, is not the same. The degree of digestion in the case when papain has been activated by sodium thiosulphate with 8-hydroxyquinoline compares even fairly with that brought about by the help of the enzyme trypsin. 8-Hydroxyquinoline alone exerts only a slight activating influence on the proteolytic activity of papain.

In conclusion the author wishes to express his gratitude to Dr. U. P. Basu for his help and suggestions in course of this investigation.

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DEHYDROGENASE ACTIVITY AND INORGANIC SUBSTRATES

By K. M. PANDALAI

The mechanism of oxidation process by dehydrogenases has so far been investigated almost only with organic substrates such as glucose, succinic acid, xanthine, lactic acid etc. There are, however, oxidations *in vivo* where the energy liberated by inorganic chemical processes serve to raise the energy potential of carbon dioxide in the assimilation process. Among these may be mentioned the oxidation of ammonia, nitrite, sulphur, hydrogen sulphide etc., by the respective chemosynthesising autotrophic bacteria.

According to Wieland (*Ergeb. Physiol.*, 1922, **20**, 477) a great majority of biological oxidations is essentially dehydrogenations and practically all oxidations of organic compounds *in vivo* actually produce a loss of hydrogen atoms. It has been shown by the author (*Biochem. Z.*, 1939, **300**, 122 ; *Science*, 1936, **84**, 440) that the biological oxidation of ammonia by the nitrosobacteria does not involve an activation of hydrogen and that ammonia never becomes a hydrogen donator in the presence of organisms known to possess dehydrogenase activity. It was also made clear that nitrifiers lacked the power of activating the hydrogen of any given organic substrate.

The question thus arose whether the incapacity of organisms of established dehydrogenase activity to activate inorganic hydrogen was a general property of the group. Preliminary experiments, now completed with a view to elucidating the mechanism of oxidation by autotrophic agencies in inorganic substrates, and that by heterotrophic systems in organic substrates, show that dehydrogenases procured from various well known sources are incapable of hydrogen activation so long as the hydrogen is in inorganic combination.

TABLE I

Temperature, 37° in all cases.

No.	Source of the dehydrogenase. 2 c.c. of the enzyme present in phosphate buffer (pH 8)	Substrates, 2 c.c. $M/140$ each Omeliansky soln. 2 c.c.	Rate of reduction of 0.00034 M Methylene blue.
1.	*B.coli*	Glucose solution	+ + +
		Omeliansky solution	− − −
		Ammonium carbonate solution	− − −
2.	Azotobacter	Glucose solution	+ + +
		Omeliansky solution	− − −
		Ammonium carbonate solution	− − −

No.	Source of the dehydrogenase. 2c.c, of the enzyme present in phosphate buffer (pH 8)	Substrates 2c.c.M/140 each Omeliansky soln. 2 c.c.	Rate of reduction of 0.00034M Methylene blue
3.	Succinoxidase from muscle	Sodium succinate solution	+ + +
		Omeliansky solution	— — —
		Ammonium carbonate solution	— — —
4.	Xanthine oxidase from milk	Hypoxanthine solution	+ + +
		Omeliansky solution	— — —
		Ammonium carbonate solution	— — —
5.	Xanthine oxidase from liver	Hypoxanthine solution	+ + +
		Omeliansky solution	— — —
		Ammonium carbonate solution	— — —
6.	Lactic oxidase from yeast	Lactate solution	+ + +
		Omeliansky solution	— — —
		Ammonium carbonate solution	— — —

+ + +   indicates rapid decolorisation

— — —   indicates no decolorisation

A solution of pure ammonium carbonate and a solution of the well known culture medium of the Nitrosobacteria of Omeliansky (*Centrl Bakt.*, 1902, II, 9, 63, 113) were among the chief inorganic substrates investigated in these experiments. The simultaneous use of the appropriate organic substrates served as reliable controls. The Tunberg technique adopted in previous studies was preferred here also in all details. The point was also made clear that Omeliansky solution or ammonium carbonate in the concentrations used were without effect on the dehydrogenase action of the enzymes studied in their respective substrates.

Various conditions of pH, temperature, and concentration of enzymes and substrates were studied. It would thus seem that dehydrogenase activity is a feature associated only with organisms of the saphrophytic group, others of a more primordial type as the autrophic nitrite-formers entirely devoid of chlorophyll or any photodynamic pigment functioning by different mechanisms. The question of activation of inorganic hydrogen by dehydrogenases and organic hydrogen by chemosynthesising bacteria is being pursued in fuller detail.

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REVIEWS

Organic Preparations—By. Conrad Weygand, Professor at the University of Leipzig. Translated and revised from the German Text Organisch chemische Experimentierkunst, Part II. Published in Leipzig in 1938. Published by Intersience Publishers, Inc. New York (1945)

It is one of the standard books on organic preparations. The chemical reactions have been arranged according to the formation of the various linkages of the carbon atom and their fission and the book consists of the following chapters (1) Formation of carbon hydrogen bonds, (2) Formation of carbon-halogen bonds (3) Formation of carbon-oxygen bonds, (4) Cleavage of carbon-oxygen bonds, (5) Formation of organic derivatives of trivalent nitrogen, (6) Cleavage of carbon-nitrogen bonds, (7) Formation of carbon-pentavalent nitrogen linkages, (8) Carbon-divalent sulfur bonds, (9) Carbon hexavalent sulfur bonds, (10) Unsaturated carbon bonds (11) Formation of carbon-carbon bonds, (12) Fission of carbon-carbon bonds and (13) Rearrangement of carbon compounds with the exception of steric rearrangements. The system followed in this book is more methodical than the divison according to reactive groups alone.

All the basic reactions have been illustrated by simple examples. The methods which have been recently used in synthetic organic chemistry have also been fully dealt with and the usefulness of the volume has been enhanced by the inclusion of a large number of references to original literature.

The volume is a valuable addition to other books on organic preparation. The students and research workers in organic chemical laboratories will derive much benefit from this book, in as much as it not only gives a detailed information regarding the particular reaction but it provides a ready reference to original literature on the subject.

D. C.

The Chemistry of the Carbon Compounds by Victor von Richter and edited by R Anschütz Vol. III—The Aromatic Compounds. Translated from the Twelfth. German Edition by A. J. Mee. Published in 1946 by Elsevier Publishing Co. Inc. New York.

The students of organic chemistry have eagerly waited for the present volume, which deals with the aromatic compounds. The publishers should be congratulated for being able to present this important volume to the advanced students of organic chemistry to whom Richter's book is absolutely essential.

The new feature of the present English Edition is that, wherever possible, the references are given to the original journals and not to *Chemisches Zentralblatt* and that the names of the authors have been added.

D. C.

A Laboratory Hand-book of Organic Qualitative Analysis & Separation by V. S. Kulkarni. Price 15 annas. Published by Dastane Brothers Home Service, 456, Raviwar Peth, Poone City.

It is an elementary book intended for the use of the B. Sc. students reading Chemistry. The charts, showing the systematic method for the identification of organic compounds will be useful to the students undergoing a course of practical training in the laboratory. The hints for the preparation of derivatives of the more common substances, provided in the book will be helpful to the students.

D. C.

STUDIES IN SULPHANILAMIDES. PART VIII. p-ACETSULPHANILAMIDE DERIVATIVES SUBSTITUTED IN N¹-POSITION BY MONO- AND DI-SUBSTITUTED THIURETS

By S. Swaminathan and P. C. Guha

The preparation and chemical properties of thirteen new N¹-substituted sulphanilamide derivatives of mono- and di-substituted thiurets are described along with those of the derivative obtained from xanthane hydride. The acetsulphanilamide compounds get completely decomposed on hydrolysis.

The well reputed sulphanilamide drugs namely, Sulphapyridine (I), Sulphadiazine (II), Sulphathiazole (III) and Sulphaguanidine (IV) possess the structural factor N-C*=N in common, the carbon atom (marked with an asterisk) being connected with another carbon or nitrogen or sulphur. The present work was undertaken with a view to finding out the bactericidal properties of compounds possessing this important grouping (N-C=N) and containing at the same time two atoms of sulphur in the hetero rings. Sulphanilamide compounds of mono- and di-substituted thiurets (V, VI) satisfy the above two factors, and in this part is given an account of the preparation of several compounds of this series, as also that derived from xanthane hydride (VII).
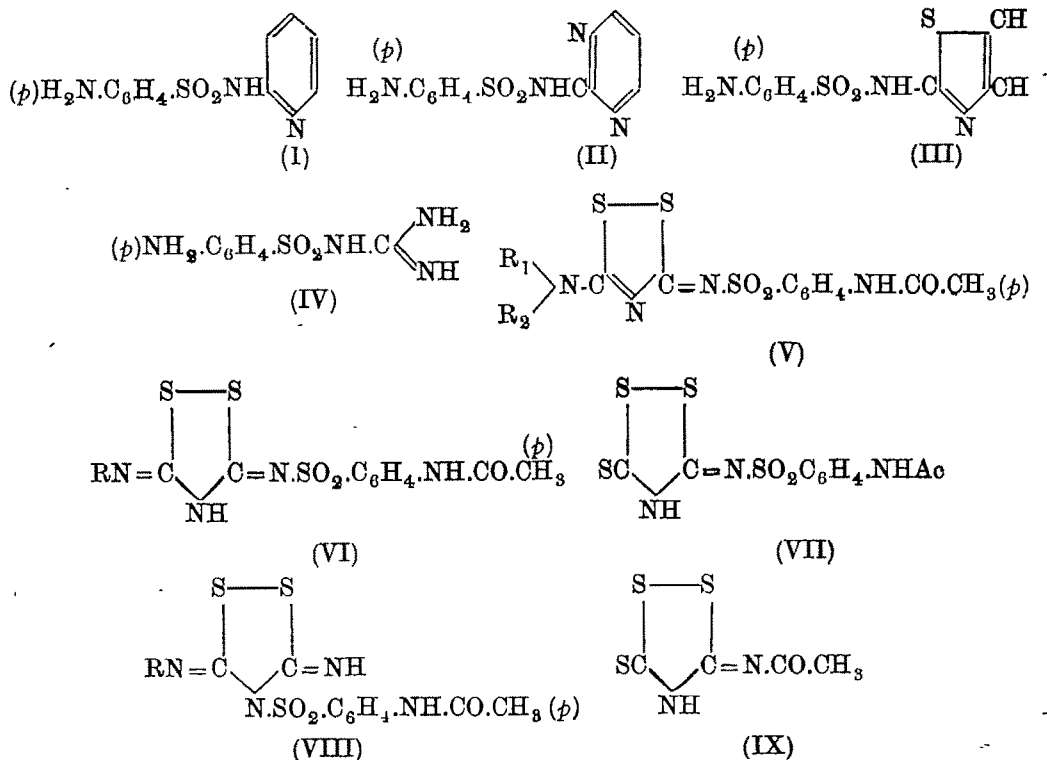
The structure of the p-acetsulphanilyl derivatives of thiurets immediately follows from that of thiurets. The derivatives of disubstituted thiurets can only have structure (V), whereas those of monosubstituted thiurets may have either (VI) or (VIII).

With alkali the acetsulphanilyl derivative of phenylthiuret decomposes into sulphur and the salts of phenyliminocyanaminothiocarbonic acid, sulphanilic acid and acetic acid. This behaviour is similar to that of acetylxanthane hydride (IX) which with alkali decomposes into sulphur, and salts of cyanaminothiocarbonic acid and acetic acid (*Annalen*, 1904, **331**, 276) and hence the acetsulphanilyl derivatives have a similar structure, namely (VI).

The aryl and aryl-alkyl thiurets have been prepared by treating primary amines or secondary amines with xanthane hydride whereby mono-ω-nitrogen substituted dithiobiurets are formed, which in turn are oxidised by iodine or ferric chloride to the corresponding monosubstituted or disubstituted thiuret hydrihalides (*Annalen*, 1893, **275**, 43 ; Bayer & Co., D.R.P., 68,697 ; *Annalen*, 1906, **347**, 171 ; 1912, **394**, 265 ; 1908, **361**, 304 ; 1907, **356**, 184 ; *Ber.*, 1884, **17**, 584 ; 1895, **28**, 1099). Attempts to extend the same method to the preparation of alkyl thiurets did not succeed. The latter have been best prepared from mustard oils which react with sodium cyanamide to give sodium salts of N-alkyl-N¹-cyanothioureas, which in turn are readily converted into the corresponding alkyl dithiobiurets on treatment with hydrogen sulphide (*Ber.*, 1892, **25**, 753 ; 1886, **19**, 449 ; 1890, **23**, 1663). The latter could be oxidised as in the previous method by iodine or ferric chloride to give the thiuret hydrihalides.

The acetsulphanilyl derivatives have been prepared by condensing *p*-acetsulphanilyl chloride with the thiuret hydrihalides (mostly hydriodides and sometimes hydrochlorides) in acetone solution in presence of pyridine. *p*-Acetsulphanilyl chloride is prepared from acetanilide by reaction with chlorosulphonic acid. The acetsulphanilyl derivatives are isolated by diluting the reaction mixture after 12 hours with enough water when the derivatives separate out and are purified by crystallisation from alcohol.

The hydrolysis of the acetsulphanilyl compounds to the free bases could not be carried out under any conditions. Both acid and alkaline hydrolysis seem to disrupt the entire molecule with the separation of sulphur and sulphanilic acid.

Attempts have been made to condense *p*-acetsulphanilyl chloride with the oxidation product of thiourea, namely *bis* (aminoiminomethyl) disulphide in the form of its dihydochloride. It will be seen that this compound has a close resemblance to thiurets. The condensation was sought to be effected in acetone medium in presence of pyridine ; but no product could be isolated by the usual method. Attempts to condense S-carbethoxy-*iso*thiourea hydrochloride and *iso*thiourea-S-formamidine under similar conditions also failed.

<div align="center">EXPERIMENTAL</div>

Xanthane hydride was prepared by Chattaway and Stevans' method (*J. Chem. Soc.*, 1897, **71**, 607).

N¹-(p-*Acetsulphanilyl*)-*phenylthiuret*.—In a 250 c.c. flask was placed phenylthiuret hydriodide (23 g.), acetone (150 c.c.) and pyridine (35 c.c.). The resulting homogeneous solution was cooled to 15-20° and well powdered *p*-acetsulphanilyl chloride (17 g.) gradually added while keeping the solution well stirred. The solution turned red as reaction started and deepened in colour with its progress. The addition took about 15 minutes. The reaction mixture was taken out of the cooling bath and allowed to stand at room temperature for 12 hours, after which it was poured into water (1 litre). The crude resin-

like product, which was precipitated, was separated by decantation, agitated with a small amount of alcohol to remove the red colour and filtered. A single crystallisation from alcohol gave the pure product, m.p. 174°, yield 12 g. (Found : C, 47.65 ; H, 3.68 ; N, 13.71 ; S, 23.85. $C_{16}H_{14}O_3N_4S_3$ requres C, 47.3 ; H, 3 45 ; N, 13.79 ; S, 23.64 per cent).

N^1-(p-*Acetsulphanilyl*)-p-*tolylthiuret*.—p-Tolylthiuret hydriodide (12 g.) was placed along with acetone (80 c.c.) and pyridine (20 c.c.) in a conical flask and the resulting clear solution cooled to 15-20°. Acetsulphanilyl chloride (8 g.) was added over a period of 15 minutes, keeping the solution well stirred. The reaction mixture was then allowed to stand overnight after which it was poured into water (600 c.c.) and the product purified as before, m.p. 167°, yield 6 g. (Found : N, 13.23 ; S, 22.5. $C_{17}H_{16}O_3N_4S_3$ requires N, 13.34 ; S, 22.87 per cent).

N^1-(p-*Acetsulphanilyl*)-o-*tolylthiuret* was prepared by interacting o-tolylthiuret hydriodide (5 g.) with p-acetsulphanilyl chloride (3.5 g.) in the presence of acetone (35 c.c.) and pyridine (10 c.c.). It was purified by crystallisation from alcohol, m.p. 164°, yield 2 g. (Found : N, 13.17 ; S, 22.67. $C_{17}H_{16}O_3N_4S_3$ requires N, 13.34 ; S, 22.87 per cent).

N^1-(p-*Acetsulphanilyl*)-o-*methoxyphenylthiuret* was obtained by interacting o-methoxyphenylthiuret hydriodide (12.6 g.) with acetsulphanilyl chloride (8 g.) in acetone medium (80 c.c.) in presence of pyridine (20 c c.). Isolation and purification as before, m.p. 153°, yield 6 g. (Found : N, 12.44 ; S, 21.83. $C_{17}H_{16}O_4N_4S_3$ requires N, 12.84 ; S, 22.02 per cent).

o-*Methoxyphenylthiuret hydridoide* was obtained by the oxidation of an alcoholic solution of o-methoxyphenyldithiobiuret with iodine. Crystallisation from alcohol as in the corresponding cases, m.p. 199-200°, yield quantitative. (Found : N, 11.31 ; S, 17.65. $C_9H_{10}ON_3IS_2$ requires N, 11.44 ; S, 17.44 per cent).

N^1-(p-*Acetsulphanilyl*)-p-*methoxyphenylthiuret* was prepared by condensing p-methoxyphenylthiuret hydriodide (6 g.) with p-acetsulphanilyl chloride (4 g.) in the presence of acetone (40 c.c.) and pyridine (10 c.c.). Isolation and purification by the usual method, m.p. 160-61°, yield 3 g. (Found : N, 12.51 ; S, 21.77. $C_{17}H_{16}O_4N_4S_3$ requires N, 12.84 ; S, 22.02 per cent).

p-*Methoxyphenyldithiobiuret* was obtained by condesning p-anisidine (10 g.) with xanthane hydride (10 g.) by heating on a water-bath for half an hour. The amine was removed by boiling with 50% alcohol (150 c.c.), the alcoholic solution chilled and the resulting crystals freed from sulphur by dissolving in 10% sodium hydroxide solution (80 c.c.), filtering the solution and acidifying the filtrate. It crystallised from alcohol, m.p. 165°, yield 10 to 12 g. (Found : N, 17.35 ; S, 26.6. $C_9H_{11}ON_3S_2$ requires N, 17.43 ; S, 26.56 per cent).

p-*Methoxyphenylthiuret Hydriodide*.—Oxidation of a saturated alcoholic solution of the dithiobiuret with iodine yielded the hydriodide which was crystallised from alcohol, m.p. 182°, yield quantitative. (Found : N, 11.52 ; S, 17.27. $C_9H_{10}ON_3IS_2$ requires N, 11.44 ; S, 17.44 per cent).

N^1-(p-*Acetsulphanilyl*)-p-*ethoxyphenylthiuret* was prepared from the corresponding thiuret hydriodide (4.1 g.) and acetsulphanilyl chloride (2.6 g.) as before, m.p. 183°, yield 2 g. (Found : N, 12.4 ; S, 21.18. $C_{18}H_{18}O_4N_4S_3$ requires N, 12.45 ; S, 21.33 per cent).

p-*Ethoxyphenylthiuret hydriodide* was obtained by oxidation of an alcoholic solution of the dithiobiuret by iodine, followed by recrystallisation from alcohol, m.p. 194°, yield quantitative. (Found : N, 10.96 ; S, 16.74. $C_{16}H_{12}ON_3IS_2$ requires N, 11.03 ; S, 16 8 per cent).

N^1-(p-*Acetsulphanilyl*)-o-*ethoxyphcnylthiuret.*—o-Ethoxyphenylthiuret   hydrochloride (6 g.) was reacted with acetsulphanilyl chloride (4.7 g.) in acetone solution (50 c.c.) in presence of pyridine (10 c.c.).   Final purification was done by crystallisation from alcohol, m.p. 189°, yield 3.5 g. (Found : N, 12.54 ; S, 21.46. $C_{18}H_{18}O_4N_4S_3$ requires N, 12.45 ; S, 21.33 per cent).

N^1-(p-*Acetsulphanilyl*)-α-*naphthylthiuret* was obtained from the corresponding thiuret hydriodide (5.5 g.) and acetsulphanilyl chloride (3.6 g.), m.p. above 300°, yield 1.4 g. (Found : N, 12.43 ; S, 21.2. $C_{20}H_{16}O_3N_4S_3$ requires N, 12.28 ; S, 21.05 per cent).

α-*Naphthyldithiobiuret.*— α-Naphthylamine (15 g.) and xanthane hydride (10 g.) were heated together on a boiling water-bath for 20-25 minutes. The excess of amine was removed as before by boiling with 50% alcohol (120 c.c.) and the purification done by dissolving in 10% alkali (80 c.c.) and reprecipitating with acid. The product was finally purified by crystallisation from acetic acid or alcohol, m.p. 246°, yield 9 g. (Found : N, 16.23 ; S, 24.4. $C_{12}H_{11}N_3S_2$ requires N, 16.09 ; S, 24.52 per cent).

α-*Naphthylthiuret hydriodide* was prepared by the usual method, m.p. 237°, yield quantitative. (Found : N, 10.77 ; S, 16.7. $C_{12}H_{10}N_3IS_2$ requires N, 10.85 ; S, 16.54 per cent).

N^1-(p-*Acetsulphanilyl*) β-*naphthylthiuret.*— β-Naphthylthiuret hydrochloride (3 g.) and acetsulphanilyl chloride (2.4 g.) were condensed together in acetone solution (30 c.c.) in presence of pyridine (5 c.c.). The acetone solution unlike in previous experiments was kept refluxing initially for an hour, and subsequently worked up as before, m.p. 217-218°, yield 2.4 g. (Found : N, 12.07 ; S, 20.86. $C_{20}H_{16}O_3N_4S_3$ requires N, 12.28 ; S, 21.05 per cent).

N^1-(p-*Acetsulphanilyl*)-*phenylmethylthiuret* was prepared as usual from acetsulphanilyl chloride (4 g.) and phenylmethylthiuret hydriodide (6 g.). Initial refluxing for an hour was found to be necessary. The product was finally crystallised from alcohol, m.p. 191°, yield 2.3 g. (Found : N, 13.18 ; S, 22.93. $C_{17}H_{16}O_3N_4S_3$ requires N, 13.34 ; S, 22.87 per cent).

N^1-(p-*Acetsulphanilyl*)-*phenylethylthiuret* was prepared by the usual method. Initial refluxing of the acetone solution was helpful, m.p. 183°, yield 41% of theory. (Found : N, 12.81 ; S, 22.04. $C_{18}H_{18}O_3N_4S$ requires N, 12.9 ; S, 22.112 per cent).

Phenylethylthiuret hydriodide was prepared and purified by the general method, m.p. 196°, yield quantitative. (Found : N, 11.39 ; S, 17.65. $C_{10}H_{12}N_3IS_2$ requires N, 11.5 ; S, 17.54 per cent).

p-*Acetsulphanilyl Derivatives of Monoalkylthiurets.*—Attempts to extend the method used for the preparation of aryldithiobiurets to alkyl dithiobiurets failed. Experiments were conducted in which xanthane hydride, dissolved in pyridine solution, was sought to be condensed with methylamine, which was bubbled through the solution, the latter being heated subsequently in an autoclave for periods of time varying from half an hour

to two hours. But nothing separated except sulphur on diluting the reaction mixture with water and adding acid. Some experiments were conducted by heating on a water-bath sealed tubes containing liquified methylamine and xanthane hydride. The corresponding dithiobiuret did not seem to be formed. Therefore the method described by Hecht was used for the preparation of alkyl dithiobiurets and therefrom the thiuret hydriodides. Methyl and allyl dithiobiurets were obtained in 50 and 27.5% yields respectively.

N-^{1}(p-*Acetsulphanilyl*) *methylthiuret* was obtained by condensing a solution of the thiuret hydriodide (5.6 g.) in a mixture of acetone (35 c.c.) and pyridine (5 c.c.) with acetsulphanilyl chloride (4.8 g.). Initial refluxing for an hour was necessary, m.p. 148°, yield 2.2 g. (Found : N, 16.32 ; S, 27.68. $C_{11}H_{12}O_3N_4S_3$ requires N, 16.28 ; S, 27.9 per cent).

Methylthiuret Hydriodide.—The procedure adopted for the preparation of aromatic thiuret hydriodides was used without any modification, m.p. 131°, yield almost quantitative. (Found : N, 15.41 ; S, 23.09. $C_3H_6N_3IS_2$ requires N, 15.27 ; S, 23.28 per cent).

N^1-(p-*Acetsulphanilyl*)*allylthiuret* —Acetsulphanilyl chloride (2.4 g.) was condensed with allylthiuret hydriodide (3 g.) in acetone medium (25 c.c.) in presence of pyridine (4 c.c.). The condensation product was isolated and purified as before, m.p. 165°, yield 1.3 g. (Found : N, 15.22 ; S, 25.84. $C_{13}H_{14}O_3N_4S_3$ requires N, 15.14 ; S, 25.95 per cent).

Allylthiuret Hydriodide.—The usual procedure of oxidation in alcoholic solution was adopted, m.p. 110-12°, yield quantitative. (Found : N, 14.06 ; S, 21.47. $C_5H_8N_3IS_2$ requires N, 13.95 ; S, 21.26 per cent).

Condensation of p-*Acetsulphanilyl Chloride with Xanthane Hydride.*—Xanthane hydride (3 g.) was reacted with p-acetsulphanilyl chloride (5 g.) in acetone (25 c.c.) in presence of pyridine (5 c.c.). The solution which turned red was left overnight and then poured into water (250 c.c.). The substance was separated by decantation of the liquid and purified by crystallisation from alcohol after treatment with norit, whereby brown crystals were obtained, m.p. 197°, yield 2.8 g. (Found : N, 11.92 ; S, 37.04. $C_{10}H_9O_3N_3S_4$ requires N, 12.11 ; S, 36.89 per cent).

Action of Alkali on N (p-*acetsulphanilyl*) *phenylthiuret.*—N^1-(p-Acetsulphanlyl)phenyl-thiuret (2 g.) was treated with an aqueous solution (10 c.c.) of potassium hydroxide (0.5 g.). In about 30 minutes, the compound was completely decomposed. The solution was filtered and the filtrate was found to answer all the reactions characteristic of salts of sulphanilic acid and cyanaminophenylthiocarbamic acid (*Ber.*, 1886, **19**, 449). Sulphanilic acid was precipitated on acidifying the solution.

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STUDIES IN SULPHANILAMIDES. PART IX. N¹-SULPHANILAMIDE DERIVATIVES OF PHENYL DIALKYLTHIOL PSEUDODITHIOBIURETS

By S. Swaminathan and P. C. Guha

p-Acetsulphanilyl chloride has been condensed with seven N¹-phenyldialkylthiol *pseudodithio-biurets* to form phenyl N¹-acetsulphanilyl dialkylthiol *pseudodithiobiurets*. The free bases from these have been obtained by hydrolysis with 10% aqueous or alcoholic hydrochloric acid.

The work described in this part was undertaken in pursuance of a programme of research to investigate the pharmacological properties of N¹-sulphanilamide derivatives of open-chain compounds containing the group $\underset{N}{\overset{N}{\diagdown}}C{-}S$ (C or N) which is present in most of the active sulphanilamide drugs (*cf* part VIII). Though quite a large number of N¹-heterocyclic derivatives of sulphanilamide containing this grouping are described in literature, only a few of the open-chain type seem to have been prepared, *e.g.* sulphanilamide derivatives of alkylthiol pseudothioureas, alkylthiol thiosemicarbazides and N-aryl-1-alkylthiol pseudothioureas (*Curr. Sci.*, 1943, **12**, 325; 1944, **13**, 205; *J. Amer. Chem. Soc.*, 1942, **64**, 1682 : *Rev. Med France*, 1941, Nov.-Dec.). Haworth and McGeorge (*Lancet*, 1943, **245**, 465; 1942, **243**, 30) have shown that thiourea and alkylthiol pseudothioureas are endowed with valuable therapeutic properties. Thiourea has also been shown to be an effective remedy against thyrotoxicosis and in combination with sulphathiazole it seems to act synergistically by inhibiting the growth of B.coli (Lee and Foley, *Proc. Soc. Expl. Biol. Med.*, 1943, **54**, 105). It was thought worthwhile therefore to prepare N¹-sulphanilamide derivatives of alkylthiol compounds of alkyl and aryl pseudodithiobiurets.

For the purpose of preparing N¹-sulphanilamide derivatives, it is obvious that the unsubstituted and the monoalkylthiol derivatives of pseudodithiobiurets (both

$$\underset{\underset{\text{(1)}\dot{S}R}{|}}{R.\overset{a}{N}}=\overset{b}{C.NH_2}.CS.NH_2 \quad \text{and} \quad R.NH.CS.NH.\underset{\underset{\dot{S}R}{|}}{C}=NH$$
$$(2)$$
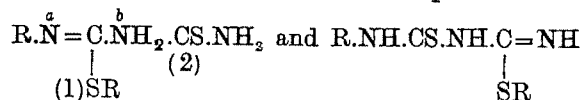
will not be of much use, since these are definitely acidic and will not condense with *p*-acetsulphanilyl chloride. It was expected, however, that substitution at both the sulphur atoms by alkyl groups in aryldithiobiurets would furnish compounds possessing pronounced basic character and hence should condense with *p*-acetsulphanilyl chloride. This expectation has now been realised.

There are two possible methods of preparing the dialkylthiol compounds in both of which the monoalkylthiol compounds are first prepared and then again alkylated. It is easily seen from the accepted formula of phenyldithiobiuret that two structurally different (excluding tautomeric forms) monoalkylthiol pseudodithiobiurets are possible, *viz* . (I) and (II),

$$\underset{\underset{\dot{S}R(i)}{|}}{C_6H_5N}=C{-}NH.CS.NH_2 \qquad \underset{\underset{(ii)\dot{S}R}{|}}{C_6H_5NH.CS.NH.C}=NH$$
$$\text{(I)} \qquad\qquad \text{(II)}$$
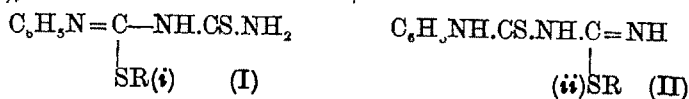
according as the substitution is at S(i) or S(ii). Each on further alkylation gives the same dialkylthiol compound, as described in the experimental part. The preparation of compounds analogous to (II) depends on the reaction, studied by Johnson (*Amer. Chem. J.*, 1903, **30**, 167) between unsubstituted pseudothioureas and *iso*thiocyanates. For example, ethylthiol pseudothiourea combines with phenyl*iso*thiocyanate to give phenyl-2-ethylthiol pseudodithiobiuret (III),

$$C_6H_5NCS + H_2N—C=NH \longrightarrow C_6H_5NH.CS.NH.C=NH$$
$$\underset{SEt}{|} \qquad\qquad \underset{SEt \ (III)}{|}$$
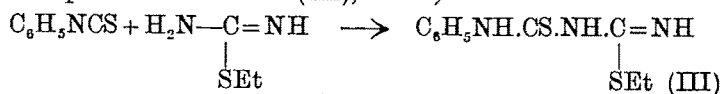
This compound on further ethylation yields the di.thylthiol compound. Compounds of type (I) are prepared by direct alkylation of mono-ω-nitrogen aryl substituted dithio-biurets in the presence of ammonia or sodium hydroxide (*Ber.*, 1884, **17**, 585). For example, phenyldithiobiuret gives phenyl-1-thiolethyl pseudodithiobiuret (IV) on treatment with an equimolecular amount of ethyl iodide.

$$C_6H_5NH.CS.NH.CS.NH_2 + C_2H_5I \longrightarrow C_6H_5N=C—NH.CS\ NH_2$$
$$\underset{SEt \quad (IV)}{|}$$
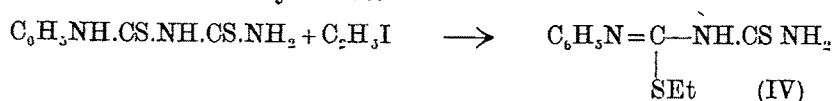
This on further ethylation gives a product, identical with that obtained by ethylating its isomer (III).

The structure of phenyldialkylthiol pseudodithiobiurets immediately, follows from the structures of the two isomeric monoalkylthiol compounds which have been assigned structures (I) and (II) by Johnson. The action of alkyl halide on the two isomeric mono-alkylthiol compounds can proceed in various ways to give structurally different products. But identical dialkyl derivatives will be produced in both cases if only the alkyl group gets attached to the other sulphur atom. That the same product is obtained by ethylation of the isomeric phenylmonoethylthiol pseudodithiobiurets convincingly shows that the dialkyl compounds are to be formulated as follows :

$$C_6H_5N=C—(SR)—NH—C—SR\ (:NH).$$
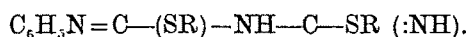
As anticipated, the phenyldialkylthiol pseudodithiobiurets proved to be strong bases and condensed with *p*-acetsulphanilyl chloride. Seven dialkyl derivatives have been prepared with methyl, ethyl, propyl, butyl, allyl, benzyl, and methylene as substituents. These are generally obtained by direct alkylation of phenyldithiobiuret with slightly more than two molecular proportion of alkyl halide in the presence of ammonia or sodium hydroxide solution without isolating the monoalkylthiol compound. The structurally isomeric monothiol compounds have been prepared, with ethyl as substituent, as mentioned in a preceding paragraph, to establish the identity with each other of the products obtained on further ethylation of each and also with that obtained by direct ethylation of phenyldithiobiuret with excess of ethyl bromide.

The condensation of each of these with *p*-acetsulphanilyl chloride is effected in acetone solution in the presence of pyridine. The reaction is initiated in a well cooled solution and allowed to continue for 12 hours at room temperature, after which the reaction mixture is poured into a large volume of water when the condensation product separates out The latter is well washed with dilute alcohol and crystallised from alcohol or acetic acid.

The hydrolysis of the acetamino compounds has usually been accomplished by warming to 50-70° with 10% aqueous hydrochloric acid for about 15-30 minutes till a clear solution is obtained. The latter is then neutralised with 10% aqueous sodium hydroxide under cooling when the free base separates out and is crystallised from alcohol after filtration.

Invariably in each case the hydrolysis of the acetamino compounds takes place concurrently with their partial decomposition as is indicated by the strong smell of mercaptans and mustard oils. The conditions of hydrolysis have to be very carefully adjusted to produce the maximum yield of the free base.

All the free bases are insoluble in alkali This indicates that there is no amido hydrogen present in the molecule and since tautomeric forms can be excluded for phenyldialkylthiol pseudodithiobiurets on the basis of Johnson's work on the hydrolysis of the isomeric monoalkylthiol derivatives (loc. cit.), the number of alternative structures for the sulphanilamide derivatives is reduced to two, viz., (V) and (VI).

$$SO_2.C_6H_4.NH_2 \ (p)$$
$$C_6H_5 \ N = C - N - C = NH \qquad\qquad C_6H_5.N = C - NH - C = N.SO_2.C_6H_4.NH_2 \ (p)$$
$$\qquad\quad | \qquad | \qquad\qquad\qquad\qquad\qquad\quad | \qquad\qquad\quad |$$
$$\qquad\quad SR \qquad SR \qquad\qquad\qquad\qquad\quad SR \qquad\qquad SR$$
$$\qquad\qquad (V) \qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad (VI)$$
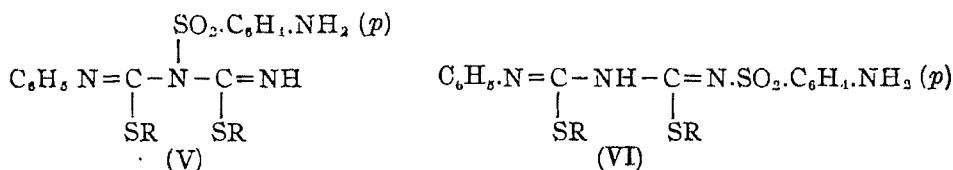
To decide between the two, a crucial experiment has been devised. The sulphanilamide derivative of phenyldiethylthiol pseudodithiobiuret is boiled with 10% alcoholic hydrochloric acid for half an hour. The solution, which smells of mercaptan, is neutralised with ammonia and the resulting precipitate crystallised from hot water. The substance thus isolated has the same melting point as sulphanilamide and does not depress the melting point of an authentic sample of the latter. The formation of sulphanilamide on hydrolysis indicates that structure (VI) is more probable for these sulpha compounds. The reaction can be visualised to take place initially as follows :

$$(VI) + H_2O \ \rightarrow \ Ph.N = C - NH - C = O$$
$$\qquad\qquad\qquad\qquad\quad | \qquad\qquad | \qquad + H_2NSO_2.C_6H_4.NH_2 \ (p)$$
$$\qquad\qquad\qquad\qquad SR \qquad SR$$
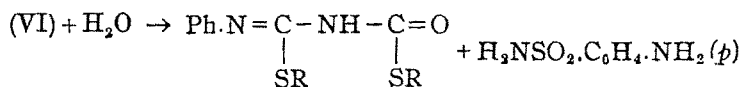
followed by the decomposition of the dialkyl derivative into mercaptans, isothiocyantes, etc.

EXPERIMENTAL

Phenyldithiobiuret was prepared adopting the procedure described in *Annalen*, 1893, **275**, 43.

N^a-*Phenyl*-1 : 2-*diethylthiol pseudodithiobiuret* was prepared by ethylation of the two isomeric monoethylthiol compounds and also by direct ethylation of phenyldithiobiuret. Phenyl monoethylthiol pseudodithiobiuret (either of the isomers prepared as described in *Ber.*, 1884, **17**, 585 ; *Amer. Chem. J.*, 1903, **30**, 167), was dissolved in a mixture of alcohol and ammonia and boiled with slightly more than 1 molecule of ethyl bromide for 3-4 hours. The mixture was cooled and poured into water when crystals mixed with oil settled down. On standing for some time in an ice-bath, complete solidification took

place. The solid was separated, treated with 10% sodium hydroxide solution and the solution filtered. The undissolved residue was crystallised from alcohol, m.p. 165° , yield 40-45%.

The same substance was obtained by treating phenyldithiobiuret with slightly more than 2 moles of ethyl bromide. Phenyldithiobiuret (5 g.) dissolved in alcohol (40 c.c.) was treated with liquor ammonia (8 c.c.) and ethyl bromide (7 g.). After about 70 minutes, the reaction mixture was diluted with water (200 c.c.) and left in ice for sometime. The solid was freed from the mono compound by treatment with 10% sodium hydroxide in which it dissolved, and the residue crystallised from alcohol twice, m.p. 165-66° , yield 1.5-2 g. (25-35%).

The identity with one another of the products obtained by the different methods was established by taking mixed melting points. In no case was any depression observed. (Found : C, 54.12 ; H, 6.53 ; N, 15.95 ; S, 24.09. $C_{12}H_{17}N_3S_2$ requires C, 53.94 ; H, 6.37 ; N, 15.73 ; S, 23.97 per cent).

N^a - *Phenyl* - N^c - (N^1- p-*acetsulphanilyl*) - 1 : 2-*diethylthiol pseudodithiobiuret* was obtained by interacting N^a-phenyl-1 : 2-diethylthiol pseudodithiobiuret (2.5 g.) in a mixture of acetone (25 c.c.) and pyridine (5c.c.) with p-acetsulphanilyl chloride (2.5 g.). The reaction was started under cooling (15-20°) and allowed to proceed afterwards at room temperature for 8 hours. On dilution with water, the red solution deposited a sticky resin-like product which was separated by decantation, washed with a small amount of alcohol and crystallised from the same solvent, m.p. 205° , yield 1.8 to 2.3 g. (Found : C, 51.91 ; H, 5.43 ; N, 12.3 ; S, 20.82. $C_{20}H_{24}O_3N_4S_3$ requires C, 51.72 ; H, 5.17 ; N, 12.1 ; S, 20.7 per cent).

N^a-*Phenyl*-N^c-(N^1-*sulphanilyl*)-1 : 2-*diethylthiol pseudodithiobiuret*.—The above acetyl compound (2 g.) was hydrolysed by warming on a water-bath maintained at 60-70° with 10% aqueous hydrochloric acid (15 c.c.) for half an hour, the clear solution was neutralised with 10% sodium hydroxide under cooling when the free base was precipitated. A single crystallisation from alcohol gave the pure substance, m.p. 153° , yield 1.1 g. (Found : C, 50.96 ; H, 5.1 ; N, 13.3 ; S, 22.98. $C_{18}H_{22}O_2N_4S_3$ requires C, 51.2 ; H, 5.21 ; N, 13.3 ; S, 22.8 per cent).

It was thought worthwhile oxidising N^c-phenyl-1-ethylthiol pseudodithiobiuret, which contains a sulphydril group, to the disulphide and trying to condense this with p-acetsulphanilyl chloride. The condensation was sought to be effected under the same conditions as obtained in the above condensation but no condensation product could be isolated.

bis-(N^a-*Phenyl*-1-*ethylthiol pseudodithiobiuret*)-2-*disulphide Hydriodide*.—To a hot saturated solution of the monoethylthiol compound in alcohol, was added an alcoholic solution of iodine till there was no more decolorisation. The solution was allowed to cool when crystals separated. These were filtered and recrystallised from alcohol, m.p. 129-30°, yield quantitative. (Found : N, 11.56. $C_{20}H_{26}N_6I_2S_4$ requires N, 11.48 per cent).

N^a-*Phenyl*-1 : 2- *dimethylthiol pseudodithiobiuret*.—Phenyldithiobiuret (10 g.) was dissolved in a mixture of 40% aqueous sodium hydroxide solution (15 c.c.) and alcohol (90 c.c.) and warmed with dimethyl sluphate (7 g.) on a water-bath for 3 hours. The solution was treated with acid till it was only slightly alkaline when a precipitate was

deposited. This was crystallised from alcohol after treatment with norit, m.p. 195°·, yield 7 g. (Found : N, 17.5. $C_{10}H_{13}N_3S_2$ requires N, 17.6 per cent).

N^a-*Phenyl*-N^c(*N^1-acetsulphanilyl*)-1 : 2- *dimethylthiol pseudodithioburet* obtained from N^a-phenyl-1 : 2-dimethylthiol pseudodithiobiuret (2.5 g.) and *p*-acetsulphanilyl chloride (2.5 g.) in acetone solution (30 c.c.) in presence of pyridine (5 c.c.), m.p. 186° , yield 2.5 g. (Found : N, 12.62. $C_{16}H_{20}O_3N_4S_3$ requires N, 12.8 per cent).

N^a-*Phenyl*-N^c-(*sulphanilyl*)-1 : 2- *dimethylthiol pseudodithiobiuret*.—The above acet amino compound (2 g.) was hydrolysed by refluxing with 10% alcoholic hydrochloric acid (13 c.c.) on a water-bath till the solution cleared. The solution was neutralised with 10% aqueous sodium hydroxide and the resulting precipitate crystallised from alcohol, m.p. 124° , yield 0.9 g. (Found : N, 14.13. $C_{16}H_{18}O_2N_4S_3$ requires N, 14.21 per cent).

N^a-*Phenyl*-1 : 2- *dipropylthiol pseudodithiobiuret* was obtained by refluxing solution of phenyldithiobiuret (6 g.) in a mixture of 40% sodium hydroxide (10 c.c.) and alcohol (60 c.c.) with *n*-propyl iodide (12 g.) for 1 hour and diluting with water. The substance separated as an oil and did not completely solidify even on standing in ice. It was separated by decantation, treated with a further amount of alkali (10%) to remove traces of monopropylthiol compound, washed with water and dried in a desiccator over potassium hydroxide for 2 days. The semisolid which was thus obtained was directly condensed with *p*-acetsulphanilyl chloride, yield 3.5 g.

N^a-*Phenyl*-1-n-*propylthiolpseudodithiobiuret*.—The alkaline washings in the last experiment deposited on neutralisation with acid the 1-propylthiol compound which was purified by crystallisation from alcohol, m.p. 81°. (Found : N, 16.53. $C_{11}H_{15}N_3S_2$ requires N, 16.6 per cent).

bis-(N^a-*phenyl*-1-n-*propylthiol pseudodithiobiuret*)-2-*disulphide hydriodide* was prepared by oxidising an alcoholic solution of the 1-propylthiol compound with iodine, m.p. 101°, yield quantitative. (Found : N, 11.18. $C_{22}H_{30}N_6I_2S_4$ requires N, 11 05 per cent).

N^a-*Phenyl*-N^c-(*N^1-acetsulphanilyl*)-1 : 2 - n - *dipropylthiol pseudodithiobiuret* was obtained by condensing *p*-acetsulphanilyl chloride (2.6 g.) with the crude N^a-phenyl-1 : 2-*n*-dipropylthiol pseudodithiobiuret (3 g.) in acetone solution (30 c.c.) in presence of pyridine (5 c.c.). The acetyl derivative was isolated and purified as usual as white crystals, m.p. 178° , yield 2.4 g. (Found : N, 11.45. $C_{22}H_{28}O_3N_4S_3$ requires N, 11.39 per cent).

N^a-*Phenyl*-N^c-(*N^1-sulphanilyl*)-1 : 2-n-*dipropylthiol pseudodithiobiuret*.—The above acetyl compound (2 g.) was hydrolysed with 10% alcoholic hydrochloric acid (15 c.c) by boiling gently on a water-bath for 20-30 minutes, m. p. 137-38°, yield 0.6 g. (Found : N, 12.62. $C_{20}H_{26}O_3N_4S_3$ requires N, 12.5 per cent).

N^a-*Phenyl*-1 : 2-n-*dibutylthiol dipseudothiobiuret*.—Phenyldithiobiuret (5 g.) was refluxed in a 6% alcoholic sodium hydroxide solution (70 c.c.) with normal butyl iodide (12 g.) for $\frac{1}{2}$ hour and left to stand overnight at room temperature. The solution was diluted with water and acidified till it was only slightly alkaline when a precipitate was deposited. This was crystallised from alcohol, m.p. 85°, yield 4.5 g. (Found : N, 13.06. $C_{16}H_{25}N_3S_2$ requires N, 13.0 per cent).

N^a- *Phenyl* - N^c - (N^1-*acetsulphanilyl*)-1 : 2 - n - *dibutylthiol pseudodithiobiuret* was obtained in the usual manner from the above mentioned dibutylthiol compound (5.25 g.)

and. *p*-acetsulphanilyl chloride (4 g.), m.p. 216°, yield 4.7 g. (Found : N, 10.61. $C_{24}H_{32}O_3N_4S_3$ requires N, 10.76 per cent).

N^a-*Phenyl*-N^c-(N^1-*sulphanilyl*)-1 : 2-*n-dibutylthiol pseudodithiobiuret*.—The acetyl compound (4. 2 g.) was hydrolysed with 10% aqueous hydrochloric acid (25 c.c.), m.p. 148°, yield 1.5 g. (Found : N, 11.74. $C_{22}H_{30}O_2N_4S_3$ requires N, 11.71 per cent).

N^a-*Phenyl*-1 : 2- *diallylthiol pseudodithiobiuret* was prepared by gently refluxing a solution of phenyldithiobiuret (5 g.) in 6% alcoholic sodium hydroxide solution (70 c.c.) with allyl chloride (5 g.) for 2 hours, m.p. 110°, yield 3 g. (Found : N, 14.51. $C_{14}H_{17}N_3S_2$ requires N, 14.43 per cent).

N^a-*Phenyl*-N^c-(N^1-*acetsulphanilyl*) 1 : 2-*diallylthiol pseudodithiobiuret* was obtained by condensing acetsulphanilyl chloride (2.5 g.) in a solution of N^a-phenyl-1 : 2-diallylthiol pseudodithiobiuret (3 g.) in a mixture of acetone (30 c.c.) and pyridine (5 c.c.). Initial refluxing for an hour was necessary, m. p. 192°, yield 2.1 g. (Found : N, 11.53. $C_{22}H_{24}O_3N_4S_3$ requires N, 11.48 per cent).

N^a-*Phenyl*-N^c-(N^1-*sulphanilyl*)-1 : 2-*diallylthiol pseudodithiobiuret*.—The corresponding acetamino compound (2 g.) was kept overnight suspended in 10% alcoholic hydrochloric acid (25 c.c.). The solution was later filtered and the free base obtained from the filtrate and purified as usual. The substance was initially obtained in the form of an oil which on standing in an ice-bath solidified, m.p. 122°, yield 0.7 g. (Found : N, 12.72. $C_{20}H_{22}O_2N_4S_3$ requires N, 12.56 per cent).

N^a-*Phenyl*-1 : 2- *dibenzylthiol pseudodithiobiuret* was obtained from benzyl chloride (6 g.) and phenyldithiobiuret (5 g.) as usual, m.p. 180°, yield 3.5 g. (Found : N, 10.81. $C_{22}H_{21}N_3S_2$ requires N, 10.74 per cent).

N^a-*Phenyl*-N^c-(N^1-*acetsulphanilyl*)-1 : 2-*dibenzylthiol pseudodithiobiuret* was obtained by the action of *p*-acetsulphanilyl chloride (1.8 g.) on N^a-phenyl-1 : 2-dibenzyltihiol pseudodithiobiuret (3 g.) dissolved in a mixture of acetone (20 c.c.) and pyridine (4c.c.), m. p. 224°, yield 1.8 g. (Found : N, 9.6. $C_{30}H_{28}O_3N_4S_3$ requires N, 9.52 per cent).

N^a-*Phenyl*-N^c-(N^1-*sulphanilyl*)-1 : 2- *dibenzylthiol pseudodithiobiuret* was obtained by the hydrolysis of the acetamino compound (1.8 g.) with 10% aqueous HCl (15 c.c.), m.p. 129°, yield 0.8 g. (Found : N, 10.07. $C_{28}H_{26}O_2N_4S_3$ requires N, 10.26 per cent).

N^a-*Phenyl*-1 : 2-*dimethylenethiol pseudodithiobiuret*.—Methylene iodide (10 g.) was boiled with a solution of phenyldithiobiuret (5 g.) in 6% alcoholic sodium hydroxide (70 c.c.) for $\frac{1}{2}$ hour and the solution left to stand by itself for 8 hours ; it was later diluted with water when a precipitate settled down and was separated and crystallised from alcohol, m p. 89°, yield 4 g. (Found : N, 18.85. $C_9H_9N_3S_4$ requires N, 18.83 per cent).

N^a-*Phenyl* - N^c - (N^1 - *acetsulphanilyl*)-1 : 2-*dimethylenethiol pseudodithiobiuret* was obtained by treating a solution of N^a-phenyl-1 : 2 dimethylenethiol pseudodithiobiuret (2.2 g.) in a mixture of acetone (25 c.c.) and pyridine (5 c.c.) with *p*-acetsulphanilyl chloride (2.2 g.). Initial refluxing for half an hour was found advantageous. The acetamino compound was isolated and purified as usual, m.p. 238°, yield 2.3 g. (Found : N, 13.52. $C_{17}H_{16}O_3N_4S_3$ requires N, 13.34 per cent).

N^a-*Phenyl*-N^c-(N^1-*sulphanilyl*)-1 : 2-*dimethylenethiol pseudodithiobiuret*.—The above acetyl compound (2 g.) was hydrolysed by refluxing with 10% alcoholic hydrochloric

acid (20 c.c.) for 20-30 minutes. The base was precipitated on neutralisation with alkali and was purified by crystallisation from alcohol after treatment with norit, m. p. 179-180°, yield 0.75 g (Found : N, 14.72. $C_{13}H_{14}O_2N_4S_3$ requires N, 14.81 per cent).

Hydrolysis of N^a*-Phenyl-*N^c*-(* N'*-sulphanilyl* *)-1 : 2-diethylthiol pseudodithiobiuret*— The sulpha compound (1 g.) was refluxed with alcoholic hydrochloric acid (30 c.c.) for 20 minutes. The solution turned red and a strong smell of mercaptan was felt. The solution was then filtered and the filtrate made alkaline with ammonia when a precipitate resulted. Concentration of the solution yielded more of the substance which was crystallised from hot water after treatment with norit, m. p. 159-60°. A mixed melting point was taken with an authentic sample of sulphanilamide and no depression was observed.

N^a*-p-Tolyl-1 ? 2-diethylthiol pseudodithiobiuret.*—It may not be out of place here to record an observation in connection with N^a-*p*-tolyl-1-ethylthiol pseudodithiobiuret which Tursini (*Ber.*, 1884, **17**, 585) was the first to prepare. His method of preparation yielded a substance which he states melted at 134° and which was verified by the authors. This substance was, however, suspected to be a mixture of the mono and the dithiol compounds and was sought to be purified by dissolving in 10% alkali and examining the alkali-soluble and insoluble portions separately. The alkaline solution on acidifying deposited the monoethyl compound which after crystallisation from alcohol melted at 138°. The alkali-insoluble portion after crystallisation from alcohol was analysed, m.p. 185°. (Found : N, 15.07. $C_{13}H_{19}N_3S_3$ requires N, 14.95 per cent).

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CONCENTRATION OF COMBINED ASCORBIC ACID IN NORMAL URINE AND THE IDENTIFICATION OF ITS ASCORBIC ACID COMPONENT *VIA* THE 2 : 4-DINITROPHENYLHYDRAZINE DERIVATIVE

By Baidyanath Ghosh

The combined ascorbic acid in the urine of normal persons has been concentrated and the 2 : 4-dinitrophenylhydrazine derivative of this ascorbic acid complex has been identified with the dinitrophenylhydrazine derivative obtained from ascorbic acid.

Existence of combined ascorbic acid in normal urine was reported by Scarborough and Stewart (*Biochem. J.*, 1937, **31**, 2231) and by Guha and Sengupta (*Nature*, 1938, **141**, 972). Further observations on urinary ascorbic acid have been made by Banerjee (*J. Indian Chem. Soc.*, 1940, **17**, 463) and Sengupta (*Ann. Biochem. Expt. Med.*, 1941, **1**, 219). Ghosh (*J. Indian Chem. Soc.*, 1939, **16**, 241, 657) observed that the excretion of combined ascorbic acid in the urine of the guinea-pig was increased when injected with sublethal doses of diphtheria and tetanus toxins, and suggested the possibility of ascorbic acid combining with certain products of metabolites as a result of infection. Similar increase of combined ascorbic acid in the urine of tubercular patients has been observed by Banerjee, Sen and Guha (*Nature*, 1940, **145**, 706 ; *Ann. Biochem. Expt. Med.*, 1941, **1**, 27). Banerjee and Guha (*Ann. Biochem. Expt. Med.*, 1942, 2, 125) have observed the disappearance of combined ascorbic acid in the urine of normal persons as well as in the urine of tubercular patients, when administered with large doses of pure ascorbic acid.

The presence of combined ascorbic acid in the normal urine, its increase during infection and its disappearance when the body is saturated with ascorbic acid, suggest the possible function of ascorbic acid in the process of detoxication. The disappearance of combined ascorbic acid from the normal urine might perhaps indicate an optimum intake of vitamin-C, though this would not probably correspond to saturation of the body (Banerjee and Guha, *loc. cit.*).

Recently Ahmad, Qureshi, Toosy and Babbar (*Ann. Biochem. Expt. Med.*, 1945, **5**, 81) have confirmed our findings of the presence of combined ascorbic acid in normal urine and its increase under pathological conditions. The nature of this combined ascorbic acid in the urine is still unknown. Investigations were carried out in this laboratory to throw light on the chemical nature of combined ascorbic acid.

The present investigation provides further evidence about the existence of combined ascorbic acid in normal human urine. A fair amount of concentration of combined ascorbic acid has been identified as its 2 : 4-dinitrophenylhydrazine derivative.

EXPERIMENTAL

Sengupta (*loc. cit.*) observed that combined ascorbic acid in the urine was sufficiently stable and its splitting required one of the following drastic treatments, namely, (*i*) sufficient lowering of p_H below 1.6 and hydrolysis on a boiling water-bath for 1 hour in an atmosphere of carbon dioxide, (*ii*) reduction by hydrogen sulphide on a boiling water-

bath for 15 minutes (*cf.* Sengupta and Guha, *loc. cit.*), and (*iii*) by prolonged treatment with hydrogen sulphide (Scarborough and Stewart, *loc. cit.*) or reduction by stannous chloride and hydrochloric acid and subsequent hydrolysis in an atmosphere of carbon dioxide (Meiklelohn and Stewart, *Biochem. J.*, 1941, 35, 761).

Sufficient quantities of urine were collected from several healthy persons and were acidified with glacial acetic acid so as to obtain 5% concentration. Aliquots of urine (100 c.c.) were subjected to the following examinations :—

(*i*)   Amounts of free, dehydro- and combined ascorbic acids in the original sample.

(*ii*)   Amounts of free, dehydro- and combined ascorbic acids remaining in the urine after keeping it for 24 hours in a refrigerator.

(*iii*)   Amounts of free, dehydro- and combined ascorbic acids remaining in the urine after shaking with 1% concentration of norit charcoal.

(*iv*)   Amounts of free, dehydro- and combined ascorbic acids left in charcoal-treated urine when kept in the refrigerator for 24 to 72 hours.

TABLE I

No. of Expt.	Nature of urine.	Mg. of indophenol reducing materials calculated in terms of ascorbic acid per 100 c.c. of urine.		
		Free.	Dehydro.	Combined.
I	Original	0.80	0.02	0.60
II	Charcoal treated	0.00	0.65	0.60
III	Original urine kept in refrigerator for 24 hours	0.65	0.15	0.60
IV	Charcoal treated urine kept in refrigerator for 24 hours	0.00	0.65	0.60
V	Charcoal treated urine kept in refrigerator for 72 hours	0.00	0.65	0.60

It will be observed from Table I that the combined ascorbic acid in the urine remained unadsorbed by charcoal. The yellow colour of the urine was, however, removed completely.

About 600 c.c. of acidified and charcoal-treated urine were evaporated under vacuum on a boiling water-bath with a view to concentrating the combined ascorbic acid in the urine. The urine was evaporated to about 65 c.c. and was taken in a receiver where on cooling glacial acetic acid was added to bring the volume exactly to 70 c.c. Portions (10 c.c.) of the above concentrated urine were estimated for the presence of free, dehydro- and combined ascorbic acids initially present after charcoal treatment and after concentration and subsequent charcoal treatment. The keeping property of the combined ascorbic acid remained unaffected when kept in the refrigerator for 24 and 72 hours. Results are tabulated in Table II.

TABLE II

Nature of urine.	Mg. of indophenol reducing substances calculated in terms of ascorbic acid per 100 c.c. of urine		
	Free.	Dehydro.	Combined.
Initially charcoal treated	0.00	3.90	3.60
Concentrated and charcoal treated	0.00	2.66	2.10
Above kept in refrigerator for 24 to 72 hours	0.00	2.66	2.10

It will be evident from Table II that about 58 % of the combined ascorbic acid remained as such during the process of concentration in *vacuo*.

10 Litres of urine were evaporated by the process described above and the volume was made up to 600 c.c. with sufficient acetic acid. The urine thus concentrated was shaken with norit charcoal for 3 to 4 times to get a clear liquid which remained light yellow in colour. Aliquots (20 c.c. each) of the concentrated urine were subjected to the following treatments and in each case the amount of indophenol reducing materials as originally present and formed after treatment with cold and hot hydrogen sulphide, were noted. A 20 c.c. aliquot weighed about 25 g. On complete evaporation of a second aliquot the solid mass weighed 10 g. and the reducing materials present were determined. From a third aliquot, the solid mass was extracted with absolute alcohol in order to remove the unnecessary salts which remained in the evaporated urine concentrate. The extraction was repeated twice for complete extraction. The unnecessary salts remaining after alcoholic extraction weighed 4 g. The alcoholic extract was evaporated in vacuum on a boiling water-bath. The pasty mass obtained after the evaporation of the alcohol gradually set to a solid mass if kept in cold inside a refrigerator. The mass weighed 6 g. and was dissolved in water and its reducing capacity was determined. The results are recorded in Table III.

TABLE III

Aliquot No.	Weight.	Mg. of indophenol reducing substances expressed in terms of ascorbic acid per 100 c.c. urine.		
		Free.	Dehydro.	Combined.
I (first)	25 g.	0.104	1.31	1.39
II · (second)	10	0.88	1.42	1.28
III (third)	6	0.43	0.80	1.03

The mass derived from the evaporation of the alcoholic extract contained a lot of salts. Apart from the salts, the amounts of indophenol reducing substances have been estimated by the use of the enzyme, ascorbic acid oxidase, (oxidation method already described); Ghosh, *loc. cit.*). Salts were removed by dialysis. The mass obtained by the method described above, was dissolved in 2.5 % acetic acid solution and dialysed in a cellophone chamber. The dialysate contained 80 c.c. of the same 2·5% acetic acid solution. The whole process of the dialysis was carried out for a period of 24 to 26 hours inside a refrigerator maintained at a temperature near about ± 4—6°. The liquid inside the cellophone was found to have increased and became lighter in colour. The outer liquid developed yellow colour. The amounts of reducing materials and the amounts of true ascorbic acid, present inside the cellophone chamber as well as in the outside, were determined. The results in Table IV give the comparative values of the non-specific reducing substances and true ascorbic acid present in the urine concentrate before and after dialysis. The liquid remained inside the cellophone chamber contained ascorbic acid only in the combined form and was devoid of free and dehydroascorbic acids.

TABLE IV

State and amounts of indophenol reducing materials and true ascorbic acid present in concentrated urine corresponding to 100 c.c. urine

A. *Before dialysis*

Reducing materials in the forms as derived by treatment with cold and hot hydrogen sulphide				True ascorbic acid (ascertained by enzymic oxidation method)			
Total.	Free	Dehydro.	Combined.	Total.	Free.	Dehydro.	Combined.
1.44	0.30	0 35	0.79	0.74	0.05	0.30	0.39

B. *After dialysis*

(i) Outside the cellophane chamber

| 0.40 | 0.147 | 0.107 | 0.15 | 0.07 | 0.00 | 0.00 | 0.07 |

(ii) Inside the cellophane chamber

| 0.00 | .. | | | 0.30 | 0.00 | 0.00 | 0.30 |

The liquid inside the cellophone chamber yielded on evaporation a small amount of solid and showed the presence of salts still remaining undialysed. Further dialysis at this stage was not carried out. 2 : 4-Dinitrophenylhydrazine derivative was prepared at this stage to identify the ascorbic acid component of the combined ascorbic acid present in this dialysed urine. The method employed in the preparation of the dinitrophenylhydrazine derivative was slightly modified from the methods described by Herbert, Hist, Percival, Reynold and Smith·(*J. Chem. Soc.*, 1933, 1270), Roe and Hall (*J. Biol. Chem.*, 1939, **128**, 329) and Damm, Scarborough and Stewart (*Biochem. J.*, 1937, **31**, 1874).

Pure ascorbic acid supplied by Hofmann la Roche was dissolved in a 2.5% acetic acid solution. An equal volume of a saturated solution of 2 : 4-dinitrophenylhydrazine hydrochloride in 2.5% chemicaly pure hydrochloric acid was added to the ascorbic acid solution and then 5 c.c. of concentrated hydrochloric acid were added to the above mixture. The mixture was then warmed for 2-4 minutes on a boiling water-bath and was kept in a thermostat adjusted at 40° for 24-40 hours. The precipitate thus obtained was allowed to remain in contact with the solution for a further period of 2 days. The precipitate was then washed after filtration with distilled water to remove excess of hydrochloric acid. By following the similar procedure the dinitrophenylhydrazine derivative from the dialysed urine inside the cellophone chamber was obtained. The precipitate formed from the dialysed urine was darker in colour and the colour remained almost unchanged even when once purified. About 10 mg. of 2 : 4-dinitrophenylhydrazine derivative were obtained by the above process from 25 litres of pooled human urine. The melting point of this dinitrophenylhydrazine derivative lies between 250° and 258°, while the dinitrophenylhydrazine derivative obtained from pure ascorbic acid melted at 268-270°. The dinitrophenylhydrazine derivative of the dialysed urine cannot be purified further due to the small amount of the material derived.

My best thanks are due to Dr. B. C. Guha for his keen interest and placing the resources of his laboratory at my disposal to carry out this investigation.

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THE STRUCTURE OF MOLECULAR COMPOUNDS. PART I. THE MAGNETIC SUSCEPTIBILITIES OF THE MOLECULAR COMPOUNDS OF SYMMETRICAL TRINITROBENZENE WITH HYDROCARBONS AND PHENOLS

By Roop Chand Sahney, S. L. Aggarwal and Mahan Singh

Magnetic susciptibities of the molecular compounds of *sym*-trinitrobenzene with hydrocarbons and phenoes have been measured and the results discussed in relation to the structure of the molecular compounds.

The structure of molecular compounds formed by the union of two different substances has been the subject of much speculation. Lowry (*Chem. Ind.*, 1924, **43**, 218) suggested that molecular compounds were obtained by the intermolecular co-ordination. Bennet and Wills (*J. Chem. Soc.*, 1929, 256) supporting the above view, pointed out that the deeper colour of the molecular compounds and the simple stoichometric ratios in which the components were present were further evidence for the chemical linkage. The electronic formulation of these molecular compounds was based on the suggestion that the nitro group with structure (I) is capable of acquiring structure (II) under certain conditions of activation

$$-N \overset{\nearrow O}{\underset{\searrow O}{}} \rightleftharpoons -N \overset{\rightarrow O}{\underset{\searrow O}{}}$$

(I)   (II)

The nitrogen of the nitro group in the activated state can thus accept a pair of electrons from amino group of amines and the compound is represented as

$$O_2N \overset{}{\underset{NO_2}{\bigcirc}} N \overset{\nearrow O}{\underset{\searrow O}{}} \text{———NH}_2Ar$$
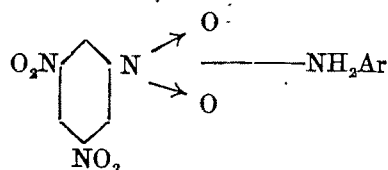
In case of molecular compounds of trinitrobenzene with hydrocarbons, one of the double bonds of hydrcoarbons acts in the polarised form as

$$\overset{\overset{-}{+}}{-\!-CH}\overset{}{-\!-}\overset{\overset{}{+}}{CH}\overset{}{-\!-}$$
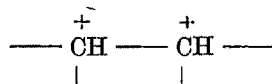
and donates a pair of electrons for the co-ordinate linkage. These views got further support from dipole moment and magnetic susceptibility measurements. Polarisation P_{AB} of molecular compounds is greater than the sum of polarisation P_A and P_B , which can only be accounted for by electronic changes (Weiss, *J. Chem. Soc.*, 1944, 64).

Bhatnagar and co-workers (*Indian J. Phys.*, 1934, 9, 131) have measured the magnetic susceptibilities of a few picrates. They attribute the differences (varying from 7.7×10^{-6} to 14.4×10^{-6}) between $\chi_{M_{AB}}$ and the sum of χ_{M_1} and χ_{M_P} to constitutive correction constant for co-ordinate linkage.

Recently, however, much evidence has been adduced against the formation of these compounds through a semipolar bond. Absorption spectra of molecular compounds of *m*-dinitrobenzene and picric acid with a number of hydrocarbons (Hunter, *J. Chem. Soc.*, 1936, 1576) indicated that they were merely superimposition of curves of two components and neither the position of maxima nor log *K* indicated anything more than a small interaction. X-ray studies of *p*-iodoaniline-trinitrobenzene compound (Powell, *J. Chem. Soc.*, 1943, 153) showed that intermolecular distances were greater than 3.5Å which excludes the possibility of any chemical bonds between molecules. Briegleb and co-workers (*Z. Physik*, 1932, **19**, 255 ; 1934, **26**, 63) after extensive investigations on the heats of interaction, dissociation, and combination concluded that the forces involved in molecular compound formation were those of interaction between a strongly polar group of one component and induced dipole in the other. The electrostatic forces thus involved are intermediate between Van der Waal's forces of attraction and true co-valencies.

In view of these later developments, a detailed magnetic study of molecular compounds therefore seemed desirable. The authors have determined χ_u of compounds of trinitrobenzene with hydrocarbons and phenols with a view to discussing their structures.

EXPERIMENTAL

The molecular compounds of *sym*-trinitrobenzene were obtained by mixing the alcoholic solutions of the components in molecular proportions and boiling the mixture for a requisite time. The product was crystallised 3 or 4 times. Great care was taken to avoid any decomposition during crystallisation.

The susceptibilities were measured by the modified form of Guoy's balance (*cf.* Nevgi, *Current Sci.*, 1935, **4**, 403). Conductivity water with $\chi_u = -72.10^{-6}$ was taken as the reference substance and the method was standardised by making determinations on compounds of known susceptibilities. The results of χ_u of known compounds with %.error are reported in Table I, χ_u of molecular compounds and components in Table II, and comparison between χ_u of compound and sum of χ_u of the components in Table III.

TABLE I

Substance.	$\chi_u \times 10^{-6}$		
	(Mean of three obs.)	Reported	Deviation
KCl	0.514	0.514	0.0%
sym-Trinitrobenzene	0.350	0.352	0.6
Naphthalene	0.719	0.717	0.3
Camphoric anhydride	0.624	0.622	0.3
Ethyl alcohol	0.743	0.744	0.1

TABLE II

R = Trinitrobenzene

No.	Substance	$\chi_M \times 10^{-6}$		
		per gram. Mean of three readings	per g. mol. experimental	per g. mol. reported
1.	R-Naphthalene	0.4781	163.03	..
2.	R-Methylnaphthalene	0 48317	171.52	..
3	R-Nitronaphthalene	0.4333	167.2	..
4	R-Bromonaphthalene	0.4491	188.66	..
5	R-Phenanthrene	0.4916	192.21	..
6	R-Anthracene	0.47729	186.62	..
7	R-Flourene	0.4522	171.38	..
8	R-Benzidine	0.4765	189.17	..
9.	R-α-Naphthol	0.4566	163.0	..
10.	R-β-Naphthol	0.46212	164.97	..
11.	R-Salol	0.4572	195.22	..
12.	R-Anthranilic acid	0.4107	143.64	..
13.	α-Naphthalene	0.719	92.03	91.77
14.	β-Methylnaphthalene	0.7231	102.66	..
15.	α-Nitronaphthalene	0.5663	97.97	97.57
16.	β-Bromonaphthalene	0.596	123.37	123.78
17.	Phenanthrene	0.719	127.98	127.8
18.	Anthracene	0.724	128.87	129.22
19.	Flourene	0.668	111.02	110.39
20.	Benzidine	0.626	115.18	..
21.	α-Naphthol	0.0708	96.595	96.91
22.	β-Naphthol	0.6722	96.79	96.91
23.	Salol	0.5777	123.62	..
24.	Anthranilic acid	0.5484	75.15	..
25.	Trinitrobenzene	0.350	74.55	74.97

TABLE III

Comparison between χ_M of molecular compound and sum of χ_M of components

No.	Compounds.	$\chi_M \times 10^{-6}$ (obs.)	Sum of χ_M of components.	Diff. between obs. and additive values.
1.	R-Naphthalene	163.03	166.58	— 3.55
2.	R-Methylnaphthalene	171.52	177.21	— 5.69
3.	R-Nitronaphthalene	167.2	172.52	— 5.32
4.	R-Bromonaphthalene	188.66	197.922	— 9.262
5.	R-Phenanthrene	192.21	202.52	—10.32
6.	R-Anthracene	186.62	203.42	—16.8
7.	R-Flourene	171.38	185.57	—14.19
8.	R-Benzidine	189.17	189.73	— 0.56
9.	R-α-Naphthol	163.0	171.145	— 8.14
10.	R-β-Naphthol	164.976	171.37	— 6.4
11.	R-Salol	195.22	198.17	— 2.95
12.	R-Anthranilic acid	143.64	149.70	— 6.06

DISCUSSION

It is clear from the values shown in Table III that these molecular compounds are less diamagnetic than the sum of the molecular diamagnetism of their components. These results are contrary to the observations of Bhatnagar, Verma and Kapur (*loc. cit.*), who showed that the molecular compounds are in general more diamagnetic than the sum of χ_M of their components. It is further evident from a close perusal of the differences tabulated in the last column of Table III that these differences increase in the order :

anthracene>flourene>phenanthrene>naphthalene>benzidine. As shown by Briegleb this is also the order of their increasing anisotropic polarisabilities.

If the molecular compound formation were due to any definite chemical interaction or the establishment of a co-ordinate linkage between the components, the difference should have been nearly the same in every case.

According to Briegleb (*loc. cit.*) the components in molecular compounds are held by forces akin to Van der Waal's type arising from the electrostatic interaction of the permanent dipole of one component and the induced dipole of the other. If this were the case, only small differences between the expreimental and additive χ_M values of the molecular compounds could be expected. It would, however, be seen that in the case of many compounds (Table III) the differences are quite large. It appears therefore that forces altogether different from those postulated by the previous workers are responsible for the formation of molecular complexes. It is probable that the various resonance forms of the components play an important part in the formation of the molecular complexes. If we take into account the relative contributions of the different forms of the components, the increase or decrease in the χ_M of the complexes from the sum of the χ_M of their components can be satisfactorily explained.

sym-Trinitrobenzene can exist in the following forms

(I, 49.48)   (II, 91.05)   (III, 84.62)
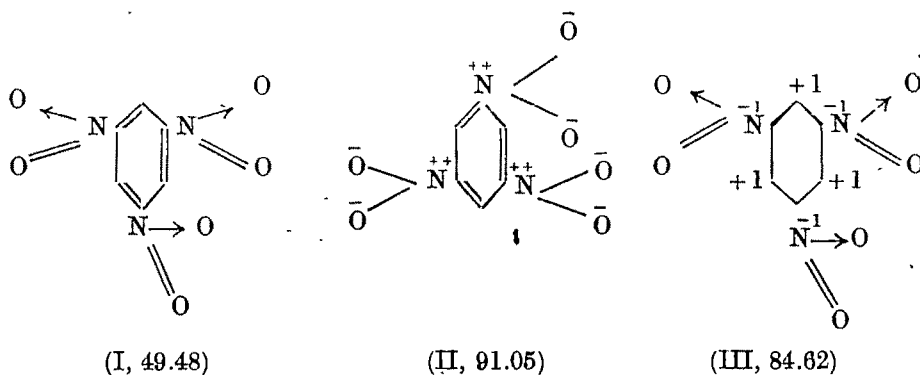
Calculations for the theoretical diamagnetism by Gray and Cruickshank's methods (*Trans. Faraday Soc.*, 1935, **31**, 1491) for the form I are given in Table IV.

TABLE IV

No. of atoms.	Charge on each.	Diamagnetism of each			Total dia-magnetism.	Bond depression.	Resultant molecular diamag-netism.
3C	—0.04	C^{-1}	0.04×14.69	$=0.587$ } $=10.149$	30.447		
		C^0	0.96×9.96	$=9.562$			
3H	0.04	H^{+1}	0.04×0	$=0$ } $=2.278$	6.834		
		H^0	0.96×2.372	$=2.278$		$3C=C$	$=28.50$
3N	1.28	N^{+2}	0.28×4.12	$=1.1536$ } $=5.4088$	16.227	$3C\text{-}C$	$=5.94$
		N^{+1}	0.72×5.91	$=4.2552$ }		$3N\text{-}C$	$=5.34$
3O	—0.34	O^{-1}	0.34×9.40	$=3.1960$ } $=7.875$	23.625	$3N=O$	$=41.70$
		O^0	0.66×7.09	$=4.6794$ }		$3N\rightarrow O$	$=1.56$
3C	0.06	C^{+1}	0.00×6.64	$=0.3984$ } $=9.7608$	20.283	$3C\text{-}H$	$=1.59$
		C^0	0.94×9.96	$=0.3624$ }			
3O	—1.0	*Vide* table		$=9.40$	28.200		
					134.616	—84.63	49.986

The calculations for the other forms are done in the same way and the values are shown below the formulae. The mean of the above calculated values is —75.22 which agrees with the experimental value of —74.8 (*vide* Table II). The above resonance structures therefore contribute equally to the equilibrium state of trinitrobenzene. The molecular diamagnetism of the polarised form (structure II) is greater than those of the other forms. Under proper conditions of activation which are provided by the presence of the second anisotropic and polarisable component, there is juxtaposition in the relative contributions of the above structures.

We take naphthalene as the second component for the sake of discussion. It has been shown by Gray and Cruickshank (*loc. cit.*) from calculations similar to those given above that the experimental diamagnetism of naphthalene (91.77×10^{-6})corresponds to the structure in which one of the two rings is in internal ionic form and the other in the double bonded (Kekule's) form. In naphthalene there is resonance between the diamagnetically equal structures I(*a*) and I(*b*).

I (*a*)	I (*b*)	II
91.87	91.87	57.716
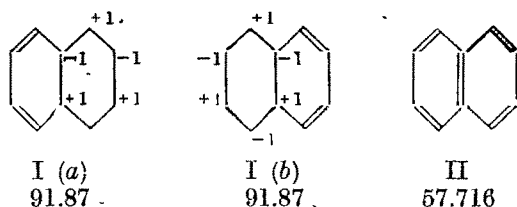
Each ring exists for half the time in the internal ionic form and for the other half in the double bonded form, *i.e.* in each ring resonance between internal ionic and double bonded structure occurs. Theoretical diamagnetism for naphthalene with both rings in the double bonded form comes out to be 57.716.

The molecular compound formation between T.N.B. and naphthalene is probably due to the greater resonance contribution of the polarised form of T.N.B. *i.e.* structure II than the other structures (I or III) and a complementary effect on naphthalene due to the electrostatic induction by virtue of which the internal ionic character of naphthalene molecule is depressed. The increased resonance energy under the above energy conditions gives stability to the molecular combination of trinitrobenzene and naphthalene. The fact that the trinitrobenzene-naphthalene compound is less diamagnetic than the sum of χ_x of its components is explained by the fact that the decrease in diamagnetism brought about by the depression of the internal ionic character of naphthalene is more than the increase due to the polarised form of T.N.B. The presence of substituent groups in naphthalene would affect the polarisability of the naphthalene nucleus, and therefore the magnitude of the depression of the internal ionic character of naphthalene would be affected by the nature of the substituent group or groups present. The observed varying differences from additivity are therefore not unexpected.

The molecular compound formation between trinitrobenzene and anthracene can be similarly interpreted. The accepted structure for anthracene is

The following are the possible interionic resonance structures for anthracene, based on the internal ionic character of the double bonded form in aromatic nuclei. Theoretical diamagnetism for these structures is calculated in the same way as given above.
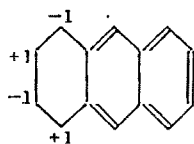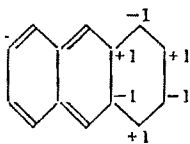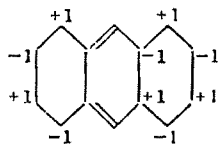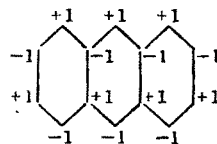
I	II	III	IV
101.71	112.62	119.26	143.949

Theoretical diamagnetism for the structure with all the rings in Kekule's double-bonded form comes out to be 76.42. The experimental value of diamagnetism of anthracene (128.87) however, shows that contribution of the internal ionic forms to the equilibrium state of anthracene is considerable.

The big difference of 16.8 units (*vide* Table III) between the experimental and the additive sum of χ_M for anthracene-trinitrobenzene compound is as explained in the case of naphthalene due to the greater internal ionic character and anisotropic polarisability of anthracene molecule.

In the formation of the molecular compounds the decrease effected in the internal ionic character of the aromatic hydrocarbons would be proportional to their anisotropic polarisabilities, because the polarisability and anisotropy will depend on the induced effect of the polarised nitro group. The fact that the differences from additivity in case of these molecular compounds increase in the increasing order of the anisotropic polarisability of the aromatic hydrocarbons lends support to the views discussed above about the structure and mechanism for the molecular compound formation. The structure of other molecular compounds can be similarly interpreted.

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INVESTIGATIONS ON HYPONITRATES. PART II.
METALLIC SALTS

By K. G. Naik, C. C. Shah and S. Z. Patel

In Part I, sodium and potassium hyponitrates were described. A number of other salts of hyponitric acid ($H_2N_2O_3$) namely, calcium, barium, strontium, lead, and cadmium hyponitrates were prepared and their properties studied. Zinc, copper and silver hyponitrates could not be prepared in a pure state.

All the insoluble metallic salts were prepared from aqueous solution of sodium hyponitrate by double decomposition. They are fairly stable and can be stocked for a long time without undergoing change.

Calcium hyponitrate is obtained as $CaN_2O_3, 4H_2O$. Angeli and Angelico, (*Gazzetta*, 1900, **30**, *i*, 593) obtained it as $CaN_2O_3, \frac{1}{2}H_2O$, and Angelico and Fanara (*Gazzetta*, 1901, **31**, *ii*, 15) described it to be $CaN_2O_3, 3\frac{1}{2}H_2O$. We obtained the barium salt as BaN_2O_3 by adding barium chloride solution to an aqueous solution of sodium hyponitrate ; however, Angelico and Fanara (*loc. cit.*) describe it as BaN_2O_3, H_2O. Strontium salt has the formula $SrN_2O_3, 2H_2O$, whereas Angeli and Angelico (*loc. cit.*) report it to be SrN_2O_3, H_2O ; and Angeli and Fanara obtained it as $SrN_2O_3, 1\frac{1}{2}H_2O$ (*Gazzetta*, 1901, **32**, *ii*, 15). Cadmium hyponitrate, CdN_2O_3, H_2O and lead hyponitrate PbN_2O_3, were obtained having the formula stated by previous investigators. The lead salt has light yellow colour ; the other salts are white crystalline powders.

Silver hyponitrate has been described by previous workers (Angeli, *loc. cit.*, Angelico and Fanara, *loc. cit.*, and Angeli and Marchetti, *Atti R. Acad. Lincei*, 1908, **17**, *i*, 695) as a very unstable compound, which decomposes spontaneously and readily changes from yellow to grey owing to rapid separation of metallic silver. All attempts to obtain silver hyponitrate in a pure state have so far failed. While precipitating this salt by mixing aqueous solutions of sodium hyponitrate and silver nitrate a grey coloured precipitate was actually obtained as described above. The estimation of nitric oxide evolved in the process and the analysis of the grey coloured residue (Ag and N_2O_3'' determination) show that the product obtained has probably the following composition : $Ag_2O.3Ag_2N_2O_3$.

No hyponitrate of zinc or copper has been described by previous investigators. Both these salts are very unstable and their decomposition is somewhat similar to that of silver hyponitrate. When attempts were made to precipitate these salts they decomposed evolving nitric oxide. The precipitate of the zinc salt obtained as a white powder, has the composition $Zn(OH)_2.ZnN_2O_3$.

The decomposition of copper hyponitrate is rather complicated. The precipitate obtained in presence of ordinary air has got a greenish blue colour and has the composition $Cu(OH)_2.CuN_2O_3$; if the precipitation is carried out in an atmosphere of carbon dioxide, a dark red precipitate is obtained, which, on analysis, was found to have the composition $Cu_2O.CuN_2O_3$.

Action of Air, saturated Aqueous Vapour and Dry Carbon Dioxide.—Calcium, barium, strontium, lead and cadmium hyponitrates are very stable and can be kept in dry air

for a long time without undergoing any decomposition. When they are exposed to dry or moist air or dry carbon dioxide, there is practically no change in weight except in the case of water vapour, where there was a slight increase in weight. The barium salt is the least hygroscopic of these. All of them retain their crystalline structure, as seen under the microscope, even on exposure to air for seven days.

Action of Water.—These salts are fairly stable when treated with water which may be due to their insolubility. The lead salt, however, becomes white ; partial hydrolysis seems to occur.

Action of Acids.—When these insoluble metallic hyponitrates are treated with acids of different dilutions, it is observed that the decomposition due to dilute acids is comparatively much less than that in the case of sodium and potassium salts. As the concentration of the acid is increased, increased quantities of nitric oxide are evolved in a given time. In the case of lead hyponitrate, the decomposition could be followed on account of the resulting change of colour, the lead salt losing its yellow colour with decomposition.

Oxidation by means of Potassium Permanganate.—The oxidation under conditions already described in Part I is similar to that observed in the case of sodium and potassium salts, resulting in the formation of nitrite to some extent, the major part of the hyponitrate being oxidised to nitrate.

Reduction.—On studying the reducing action of the reagents mentioned in Part I, the highest percentage of nitrogen reduced to ammonia was 2.50%.

Thermal decomposition.—The main course of decomposition herein may be represented as

$$MN_2O_3 = MO + 2NO$$
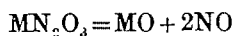
(where, M = Ba, Sr, Pb or Cd). All the alkaline earth salts decompose at a temperature higher than 320°, nitric oxide being the main gaseous product evolved. The residue left after heating is found to be alkaline and shows the presence of some nitrite and traces of nitrate. Lead and cadmium salts decompose similarly, but no nitrite or nitrate can be detected in the solid residue. The pale yellow colour of the lead salt slowly changes to deep yellow at 105°, which subsequently changes to brown at 120° and the salt loses weight, nitric oxide being evolved. The cadmium salt becomes anhydrous at 105°, slowly turning brown at 150° and decomposing at 200 leaving a brownish black residue containing no nitrite or nitrate.

EXPERIMENTAL

Preparation.—All these metallic insoluble salts were obtained as crystalline precipitates by adding a solution of the corresponding nitrate to a solution of sodium hyponitrate. The precipitate so obtained was washed with cold water, alcohol and ether and dried in a desiccator over calcium chloride.

ANALYSIS

Calcium hyponitrate :—   Found : Ca, 21·42 ; H$_2$O, 40.25, N, 14.62.
    Calculated for CaN$_2$O$_3$.4H$_2$O : Ca, 21.28 ; H$_2$O, 38.30; N, 14.90%
Barium hyponitrate :—   Found : Ba, 64.13 ; N, 13.25.
    Calculated for BaN$_2$O$_3$: Ba, 64.31; N, 13.15%.

Strontium hyponitrate :—Found : Sr, 43.75 ; N. 13.94, H_2O, 17.81.
    Calculated for $SrN_2O_3,2H_2O$: Sr, 43.90 ; N, 14.03, H_2O, 18.03%.

Cadmium hyponitrate :—Found : Cd, 54.51 ; N, 13.47 ; H_2O, 9.16.
    Calculated for CdN_2O_2,H_2O : Cd, 54.43 ; N, 13.60 ; H_2O, 8.74%.

Lead hyponitrate :—Found : Pb, 73.17 ; N, 9.80.
    Calculated for PbN_2O_3 : Pb, 73.16, N, 9.89%.

TABLE I

Oxidation with potassium permanganate (in presence of H_2SO_4)

Salt.	$KMnO_4$ (0.1N) soln. reqd. by 1 g. of salt.	Equiv. of O_2 reqd.
$CaN_2O_3,4H_2O$	319.9 c.c.	6.01
BaN_2O_3	282.7	6.03
$SrN_2O_3,2H_2O$	320.9	6.40
PbN_2O_3	217.2	6.14
CdN_2O_3,H_2O	283.8	5.85

TABLE II

Decomposition by acids

Salt	Acid used for decomp.	Salt taken.	NO evolved at N.T.P.	N_2 as NO in salt	N_2 as NO with salt	N_2 as nitrite after decompn.	N_2 as nitrate after decompn.	N_2 (total) of colms. 6, 7 & 8)	N_2 calc. per formula
CaN_2O_3, $4H_2O$	HCl	0.1116 g.	18.76 c.c.	10.51%	..	..	..	..	..
	H_2SO_4	0.0750	12.60	10.50	10.50%	4.43%	0.37%	15.30%	14.90%
	AcOH	0.1000	16.80	10.50	..	..	..	..	..
BaN_2O_3	HCl	0.0750	10.99	9.15	..	..	..	..	..
	H_2SO_4	0.0650	9.52	9.16	9.15	4.30	..	13.45	13.15
	AcOH	0.1000	14.64	9.15	..	..	..	..	..
SrN_2O_3, $2H_2O$	HCl	0.1049	17.10	10.18	..	..	..	..	..
	H_2SO_4	0.110	17.60	10.01	10.12	4.00	..	14.12	14.03
	AcOH	0.0700	11.40	10.18	..	..	..	..	..
PbN_2O_3	HCl	0.0800	7.94	6.28	..	..	..	..	..
	H_2SO_4	0.1000	9.92	6.20	6.23	3.60	..	9.83	9 89
	AcOH	0.1000	9.94	6.21	..	..	..	..	..
CdN_2O_3, H_2O	HCl	0.0940	12.03	8.00	..	..	..	..	..
	H_2SO_4	0.1000	12.80	8.00	8.03	5.60	..	13.63	13.60
	AcOH	0.0750	9.70	8.10	..	..	..	..	..

CHEMISTRY DEPARTMENT,
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STUDIES ON THE ADSORPTION OF QUININE BY DIFFERENT ADSORBENTS WITH A VIEW TO ITS EXTRACTION FROM VERY DILUTE SOLUTIONS

By B. N. Ghosh and Ava Khan

The adsorption of quinine from very dilute aqueous solution (0.05-0.15%) on various adsorbents has been investigated. Of the adsorbents tried activated charcoal was found to adsorb as much as 96%, Fuller's earth 86% and kaolin 62% quinine. The results indicate a possible method of extraction of quinine from very dilute solutions by adsorbents and subsequent elution with suitable solvents.

The main source of quinine is the cinchona plant. Its bark contains 4 to 5%, while the leaves and the woody portions contain only about 0.25% and 0.45% respectively of the alkaloids on the basis of dry weight. At present quinine is extracted only from the bark, leaves and the wood being rejected. The main difficulty in its extraction from the wood is that the extract becomes very dilute with respect to the alkaloid and hence cannot be subjected effectively to the same treatment as is followed in the case of the bark. The problem therefore is to find out an easy method of concentrating the extract. One of the possible methods that occurred to us is to remove, as completely as possible, the alkaloids from the dilute solution by adsorption on a suitable adsorbent and then to obtain a concentrated solution of it by elution from the surface of the adsorbent. With this object in view, the adsorption of quinine from very dilute aqueous solutions, using a number of adsorbents, has been investigated by us.

Malquori and co-workers (*Ann. Chim. Appl.*, 1932, **22**, 448) report that the Freundlich adsorption isotherm is applicable to the adsorption of quinine by a number of adsorbents, while Brintzinger and co-worker (*Kolloid Z.*, 1936, **74**, 29) have found that the adsorption of the alkaloid by charcoal depends considerably on the degree of activation of the adsorbent. In this experiment we have confined ourselves to a study of the adsorption of quinine from very dilute solutions of regulated p_H. The results obtained are recorded in this paper.

Experimental

Preparation of Adsorbents

Aluminium hydroxide used in these experiments was prepared by Willstätter's method (*Ber.*, 1923, **56**, 149, 1117). The suspension was prepared with 2.168 g. of Al_2O_3 per 100 c.c.

Hydrated manganese dioxide was prepared as follows: To a boiling solution of 250 c.c. of 10% $MnSO_4$ (manganous sulphate) acidified by 12.5 c.c. of 20% sulphuric acid, 450 c.c. of 5% $KMnO_4$ were added. The mixture was then allowed to settle and cool, after which the clear solution was decanted off, and the precipitate of manganese dioxide washed repeatedly with distilled water until it was free of acid and the p_H of the wash liquid was about 6.0. The moisture content of this sample of manganese dioxide was 46.24%.

Silicic acid.—Merck's silica was used but since it was found to give a faintly alkaline reaction, it was digested with strong HCl and washed with distilled water till free from acid and p_H of the wash liquid was about 6.6.

Kieselghur was washed free from all electrolytes and dried in air.

Kaolin.—The sample, obtained from the market, was observed to give a faintly alkaline reaction. It was therefore digested with moderately strong HCl as in the case of silica and then washed with distilled water, till the wash liquid showed a p_H of 6.6.

Tin oxide was prepared by treating metallic tin with strong nitric acid in a fume chamber. After heating for two hours on a water-bath to drive off the nitrous fumes, it was allowed to cool. The mass was then washed with distilled water to remove the acid, dried in air and used as adsorbent.

Fuller's earth was carefully washed with distilled water till free from all electrolytes and the p_H of the wash water was about 6.6. The washed mass was then dried in air before being used for experimental purpose.

Active charcoal.—The sample of active charcoal used was from Action Moussel Co.

Estimation of Adsorption of Quinine Sulphate

A 0.15% stock solution of quinine sulphate was prepared in distilled water with the addition of a few drops of sulphuric acid to enhance its solubility in water. For each experiment an aliquot part of this solution was taken in a bottle, made up to 100 c.c. by the addition of distilled water, if necessary, and the p_H adjusted to 6.8 to 7.0 by the addition of a few drops of alkali. A known weight (usually 1 g.)* of the air-dried solid adsorbent was then added to this solution and the mixture shaken vigorously for about 20 minutes in a mechanical shaker. The content of the bottle was then filtered and the amount of the alkaloid in an aliquot portion of the filtrate was estimated in the following way.

The filtrate, thus obtained, was rendered alkaline by the addition of caustic soda and the alkaloid extracted by shaking with a mixture of 3 parts by volume of ether and one part by volume of chloroform, in the proportion (by volume) of the mixture to filtrate as 24 : 100. The chloroform-ether mixture was then withdrawn and the extraction of the filtrate repeated twice. The chloroform-ether extracts were then mixed, washed once only with a few c.c. of water and then transferred to a glass basin and evaporated to dryness on a water-bath. A few drops of alcohol were then added to the residue and again evaporated to dryness. The basin was then dried in an air-oven, cooled in a desiccator and weighed. From these data the amount of quinine present in the supernatant solution after adsorption was calculated.

The quinine content of the stock solution was also determined in the same way and thus knowing the quinine concentration before and after adsorption, the amount of quinine adsorbed per gram of the adsorbent was calculated.

The results are recorded in Table I. The p_H of the quinine sulphate solution was in all cases adjusted between 6.8 and 7.0 unless otherwise stated. All the measurements were carried out at room temperature (30°). The amount of the adsorbent used was always 1 g. per 100 c.c. of the experimental solution.

*In the case of aluminium hydroxide the procedure was slightly different, since this adsorbent was not used in the form of air-dried solid but as a suspension. For this reason 10 c.c. of the suspension were added to aliquot portions of the stock alkaloid solution and the total volume made up to 100 c.c. by the addition of water, after which the p_H was adjusted to 6.8—7.0

TABLE I

Conc. of quinine sulphate soln.	Amount of quinine per 100 c.c. soln. before adsorption.	Amount of quinine per 100 c.c. of filtrate after adsorption.	Wt. of quinine adsorbed.
1	2	3	4
*(a) Aluminium hydroxide**			
0 05%	0 0371 g.	0 0259 g.	0.0112 g.
0.10	0.0742	0.0557	0.0185
0.15	0.1113	0.0861	0.0252
(b) Hydrated manganese dioxide.			
0.05	0.0371	0.0111	0.026
0.075	0.0556	0.0205	0.035
0.10	0.0742	0.0302	0.044
0.125	0.0927	0.0397	0.053
0.15	0.1113	0.0513	0.060
(c) Silicic acid.			
0.05	0.0371	0.0241	0.013
0.10	0.0742	0.0542	0.020
0.15	0.1113	0.0843	0.027
(d) Kieselguhr.			
0.05	0.0371	0.0201	0.017
0.075	0.0556	0.0306	0.025
0.10	0.0742	0.0422	0.032
0.125	0.0927	0.0537	0.039
0.15	0.1113	0.0663	0.045
(e) Kieselguhr (p_H adjusted at 6.0).			
0.05	0.0371	0.0071	0.030
0.075	0.0556	0.0116	0.044
0.10	0.0742	0.0182	0.056
0.125	0.0927	0.0237	0.069
0.15	0.1113	0.0303	0.081
(f) Kaolin.			
0.05	0.0371	0.0111	0.026
0.075	0.0556	0.0176	0.038
0.10	0.0742	0.0262	0.048
0.125	0.0927	0.0337	0.059
0.15	0.1113	0.0433	0.068
(g) Tin oxide.			
0.05	0.0371	0.0221	0.015
0.10	0.0742	0.0462	0.028
0.15	0.1113	0.0733	0.038
(h) Fuller's earth.			
0.05%	0.0371 g.	0.0031 g.	0.034 g.
0.075	0.0556	0.0066	0.049
0.10	0.0742	0.0132	0.061
0.125	0.0927	0.0117	0.081
0.15	0.1113	0.0153	0.096
(i) Active charcoal.			
0.05	0.0371	0.0002	0.0369
0.075	0.0556	0.0003	0.0583
0.10	0.0742	0.0005	0.0737
0.15	0.1113	0.0006	0.1107

*Aluminium hydroxide as an adsorbent was used as a suspension containing 2.168 g. of Al_2O_3 per 100 c.c. of the suspension. Since 10 c.c. were only used per 100 c.c. of quinine solution of different concentrations the weight of the adsorbent used per 100 c.c. of quinine solution was 0.2166 g. of Al_2O_3.

From the data recorded in Table I the adsorbing power of the substances studied appears to run in the order : charcoal>Fuller's earth>kieselguhr>kaolin>manganese dioxide>tin oxide>silicic acid.

It will also be noticed that charcoal adsorbs quinine very strongly. Experiments, were therefore carried out varying the quantities of charcoal at a definite concentration of quinine sulphate. Results appear in Table II (A) from which it will be noticed that 0.6 g. of charcoal can adsorb 0.1105 g. of quinine, while 0.3 g. can adsorb as much as 0.1012 g.

TABLE II

Effect of varying the quantity of absorbent on adsorption.

A. Quinine sulphate solution. Vol.=100 c.c. p_H=6.0. Conc. of quinine=0.15%. Amount of quinine per 100 c.c. before adsorption=0.1113 g.			B. Tota quinine sulphate solution. Vol.=100 c.c. p_H=6.0. Conc. of alkaloid=0.15%. Amount of alkaloid per 100 c.c. before adsorption=0.1348 g.	
Wt. of adsorbent.	Amt. of quinine per 100 c.c. after adsorption.	Wt. of quinine adsorbed per g. of adsorbent.	Amt. of alkaloid per 100 c.c. after adsorption.	Wt. of alkaloid adsorbed per g. of adsorbent.
1.0 g.	0.0006	0.1107	0.0002	0.1346
0.8	0.0007	0.1105	0.0005	0.1343
0.6	0.0008	0.1105	0.0008	0.1340
0.4	0.0023	0.1090	0.0017	0.1331
0.3	0.0041	0.1072	0.0032	0.1316
0.2	0.0096	0.1017	0.0076	0.1262

* The p_H of water in presence of the active charcoal was found to be 5.8. The p_H of the quinine sulphate solution was therefore adjusted at 6.0 in this case. The mixture of the alkaloid solution with the adsorbent was shaken for 30 minutes instead of 20 mins. as in the case of other adsorbents.

Adsorption of Tota quinine by Charcoal.—A stock solution (0.15%) of tota quinine sulphate was prepared and experiments were carried out using varying quantities of charcoal in contact with a given concentration of tota quinine sulphate solution. The p_H was adjusted to 6.0. Results have been represented in Table II(B).

Evidently charcoal adsorbs quinine and specially tota quinine very strongly hence the possibility of elution of these alkaloids from the charcoal surface was next investigated.

Elution from Charcoal.—For this purpose two experiments were done using quinine and tota quinine. Quinine sulphate (5 g.) was dissolved in water with 10 c.c. of H_2SO_4 (10%). The volume of the solution was made up to 5 litres with water. The p_H of this quinine solution was adjusted to 6.0 and 25 g. of charcoal were added to it and the mixture was stirred using a mechanical stirrer for 2 hours. The solution was then filtered. The total volume of the filtrate was taken and its quinine content estimated. The adsorbent was weighed and half of it was taken and mixed thoroughly with 1/8th of its weight of sodium carbonate. The mixture was extracted three times in succession, using 400 c.c., 300 c.c. and 300 c.c. respectively of a benzene and amyl alcohol mixture at about 80°. From the total volume of the benzene-amyl alcohol mixture 50 c.c. were extracted with 20 c.c. of H_2SO_4. The quinine passed into the acid solution which was separated and then treated with slight excess of alkali to liberate the alkaloid and extracted with an ether-chloroform mixture (3 parts of ether and 1 part of chloroform). The

alkaloid content of this extract was estimated in the way described before. The same procedure was followed in the case of tota quinine. The results of the two experiments are given below. It will be observed that the percentage of quinine eluted was 84% and that of tota quinine 82%.

Quinine :—Volume of 0.1% quinine sulphate solution taken = 5000 c.c. which contains 5 g. of quinine sulphate or 3.71 g. of quinine.

Adsorbent used = 25 g.

Amount of quinine = 3.701 g.

Amount of quinine eluted from the adsorbent = 3.108 g.

Hence the percentage of quinine recovered = 84%.

Tota quinine :—Volume of 0.1% tota quinine sulphate solution taken = 5000 c.c. which contains 5 g. tota quinine sulphate or 4.49 g. tota quinine.

Adsorbent used = 25 g.

Amount of alkaloid adsorbed = (4.49 × 0.0075) = 4.48 g.

Amount of alkaloid eluted from the adsorbent = 3.7069 g.

Hence the percentage recovered = 82%.

CONCLUSION

Of the various adsorbents which have been tried, activated charcoal has been found to have the highest capacity of adsorption. As much as 96% of the quinine are adsorbed from a 0.15% solution by an amount of activated charcoal which is only twice the weight of the quinine sulphate taken. Of the remaining adsorbents, Fuller's earth and Kieselguhr also give good results, adsorbing about 86% and 62% of quinine respectively. These results indicate the possibility of utilising the phenomenon of adsorption in concentrating the cinchona alkaloids in a small volume of adsorbent from very dilute solutions, such as those likely to be obtained in the extraction of cinchona wood by treatment with acid solutions. Although active charcoal appears to be the best adsorbent, yet Fuller's earth or kaolin may be effectively used, if the adsorption is carried out in two or three successive stages. At p_H 6.0 kieselguhr also acts as a good adsorbent.

Our grateful thanks are due to Mr. S. C. Sen, Superintendent, Government Cinchona Cultivation, Mangpoo, for supplying us a sample of pure quinine.

APPLICATION OF MIXTURE LAW TO RHEOCHOR

By W. V. BHAGWAT AND KESHAVRAO MANDLOI

The rheochor values obtained by mixture law fall with the increase in temperature in case of acetic acid, urea and acetamide and show a closer approximation to the calculated values at higher temperatures. Monochloroacetic acid behaves differently.

Bhagwat and Tosniwal (*J. Indian Chem. Soc.*, 1944, **21**, 30) have advanced the view that solution method may be applicable to rheochor also and hence suggested that like parachor, rheochor can be determined by the solution method both for liquids and solids by the expression,

$$R_m = R(1-x) + x.R_x$$

where R_m is the rheochor of the solution, R, the rheochor of the solvent, R_x, the rheochor of the solute and x, the molecular fraction of the solute. R_m is given by the expression

$$R_m = \frac{M_m \ \eta_R^{\frac{1}{8}}}{D}$$

where M_m is the mean molecular weight of the solution, η, the viscosity of the solution, D, the density of the solution. M_m is obtained from the equation,

$$M_m = M(1-x) + M_x ,$$

where M is the molecular weight of the solvent and M_x is the molecular weight of the solute.

We have determined the viscosities at room temperature and at the boiling point of water. The viscosity at the room temperature was determined as usual.

To determine the viscosity at the boiling point of water the viscometer is fitted up by means of a cork into a conical flask of about one litre capacity. Through the cork passes a tube bent at right angles to let the steam out. The viscometer is thoroughly cleaned, dried and filled with a known volume of the liquid (whose viscosity is required). By means of the rubber tubing liquid is sucked in the narrower tube of the viscometer till the level of liquid is a little above the upper mark, and the rubber tubing closed by means of a pinch-cock. This is done to avoid the formation of air-bubbles, which invariably takes place if the sucking is done when the water is boiling, and causes an obstruction in the downward flow of the liquid, resulting in the fluctuation of the value of time of fall for the liquid through the capillary. The flask is filled with enough water to cover the upper mark, and heated, some porous pieces being put in the flask to cause regular boiling. When the water has been boiling for about 15 minutes, so that the liquid in the viscometer attains the temperature of boiling water, the time of fall for the liquid between two fixed marks is noted by a stopwatch. The temperature of the liquid is also noted.

The viscometer is cleaned, dried, and after filling with an equal volume of water, the time of fall for the water is determined exactly as in the case of the liquid.

The viscosity is calculated by the usual expression and rheochor is calculated by Newton Friend's formula. Results obtained are given below

TABLE I

Rheochor of water at different temperatures

Temp.	Density.	Viscosity.	Rheochor.	Temp.	Density.	Viscosity.	Rheochor.
20°	0.9982	10.05	24.19	25°	0.9979	8.937	23.59
20.6	0.9981	9.926	24.03	30	0.9957	8.007	23.45
21.6	0.9979	9.694	23.96	40	0.9926	6.560	22.94
22	0.9978	9.605	23.94	50	0.9881	5.490	22.59
22.5	0.9977	9.638	23.92	97	0.9605	2.936	21.13

The values of density and viscosity shown in the above table are taken from standard tables.

TABLE II

Rheochor of methyl alcohol in water

Rheochor (calc.) = 49.3.   Temp. = 25°.

x	M_m.	D.	η.	R_m.	R_x.
0.3578	24.06	0.9221	14.25	36.24	58.89
0.2948	22.14	0.9313	14.26	33.16	56.08
0.2681	21.75	0.9387	14.61	32.47	56.69
0.1282	19.79	0.9679	12.47	28.05	58.34

The values at room temperature are high. Due to rapid evaporation of methyl alcohol at the boiling point of·water, results could not be obtained.

TABLE III

Rheochor of acetic acid in water

Rheochor (calc.) = 74.   Temp. = 25°.

x.	M_m.	D.	η.	R_m.	R_x.
0.1617	25.06	1.049	15.72	33.70	84.14
0.1338	23.62	1.040	11.92	31.00	80.41
0.1141	22.79	1.038	13.52	30.40	83.35
0.0780	21.17	1.028	12.02	28.21	82.81
0.0638	20.68	1.026	11.51	27.36	82.60
1.0000	60.00	1.047	9.605	..	76.03

The results are higher but they approach theoretical value at the boiling point of water.

TABLE IV

Rheochor of acetic acid in water at different temperatures

19.789 g. of acetic acid dissolved in 34.4386 g. of water. $x = 0.1338$, $(1-x) = 0.8662$, $M_m = 23.62$.

Temp.	D.	η.	R_m.	R_x.
30°	1.040	13.33	31.39	82.21
40	1.036	10.57	30.63	80.41
50	1.032	8.332	29.84	76.83

TABLE V

Rheochor of acetic acid in water at boiling point.(97°).

x.	M_m.	D.	η.	R_m.	R_x.
1.0000	60.0	1 003	4.527	..	72.24
0.3748	33.74	1.037	5.573	40 32	72.35
0.1795	25.53	1 028	4.684	30.12	71.19
0.06703	21.00	1 020	3 681	24.24	69.00

TABLE VI

Rheochor of acetamide in water at 22.5°.
Rheochor (calc.) = 72.7

x.	M_m.	D.	η.	R_m.	R_λ.
0.07575	21.10	1.015	14.70	29.09	91.62
0.07191	20.94	1.013	17.16	29.49	100.6
0.04290	19.76	1.009	12.62	26.89	92.3
0.03629	19.49	1 007	11.49	26.27	89.28
0.03616	19.48	1 007	11.55	26.69	100.7
0.02282	18.94	1.006	12.22	25.75	102.1

The results as accepted are higher at room temperature ; but they fall at the boiling point.

TABLE VII

Rheochor of acetamide in water at 97°.

x.	M_m.	D.	η.	R_m.	R_γ.
0.07291	21.00	1.012	3.946	24.63	69.11
0.0702	20 99	1.012	3.752	24.62	70.94
0.0429	19.76	1.006	3 650	23.10	57.27
0.03629	19.49	1 003	3.303	22.51	59.24
0.0303	19.36	1 001	3.342	22.47	61.76
0.0329	19.35	0.999	3.350	22.53	63.83
0.03204	19.37	1.001	3.877	22.95	84.64
0.03099	19.17	1.004	3.387	22.29	60.66
0.02832	19.15	1.006	3.402	22.20	58 96

TABLE VIII

Rheochor of urea in water at room temperature (21.6°).
Rheochor (calc) = 64 00.

x.	M_m.	D.	η.	R_m.	R .
0.07068	20.92	1.053	12.23	27.04	67.48
0.0565	20.43	1.049	11.57	26.44	68.01
0.05343	20 20	1.045	11.01	26.09	64.04
0.04201	19.78	1.036	10.72	25.68	65.00
0.0219	18.92	1.021	9.356	24.62	54.34

The results fairly agree at room temperature but fall as the temperature is increased.

TABLE IX

Rheochor of urea in water at 96°.

x.	M_m.	D.	η.	R_m.	R_λ.
0 07845	21.29	1.054	3.928	23.95	57.11
0.06916	20.90	1.048	3.873	23.61	56.97
0.06550	20.76	1.048	3.872	23.36	55.24
0.06548	20.75	1.047	3.803	23.42	56.19
0.04586	19.92	1.031	3.525	22.61	53.42

Rheochor of monochloroacetic acid in water at 20.2°.

Rheochor (calc.) = 97.1.

x.	M_m.	D.	η.	R_m.	R_x.
0.05294	22.07	1.086	15.10	28.52	92.55
0.03355	20.56	1.056	12.54	26.71	99.56
0.02510	19.92	1.045	11.58	25.89	102.0
0.02477	19.90	1.041	11.95	26.07	106.1
0.02204	19.69	1.042	12.08	25.80	98.95
0.01308	19.00	1.025	11.07	25.03	98.65

Rheochor of monochloroacetic acid in water at 96°.

0.04348	22.13	1.062	3.517	24.33	115.2
0.0356	21.43	1.067	3.975	23.86	111.5
0.0240	19.84	1.040	3.567	22.37	110.4
0.01816	19.30	1.032	3.534	22.00	119.0

Monochloro-acetic acid shows a peculiar behaviour, that its rheochor values increase with temperature.

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POLARITY OF MOLECULES IN RELATION TO THEIR ADSORPTION BY CHARCOAL

BY PROMODERANJAN GUPTA AND PADMALOCHAN DE

Opinions vary as to the influence of polarity of the adsorbate molecules and also that of the solvent used, on the adsorption of substances by activated charcoal. The present work was carried out with a view to throwing light on some of these controversial points. Effect of introducing different polar groups on adsorption was evident from the following series: $C_6H_5COOH > C_6H_4(OH)COOH$ and $CH_2ClCOOH > CH_3COOH$, $CH_2(OH)COOH > CH_2NH_2COOH$—chloro group has a tendency to increase the adsorption, while both OH and NH_2 groups decrease it, the effect of the amino being greater.. Effect of specific grouping into a benzene ring was studied with compounds like $C_6H_5NH_2$, $C_6H_5(OH)$, C_6H_5COOH, and $C_6H_4(OH)COOH$ in different media like H_2O, $CHCl_3$, C_6H_6 with the result: $C_6H_5NH_2 > C_6H_5(OH)$ $C_6H_5COOH > C_6H_4(OH)COOH$ (H_2O medium); $C_6H_5(OH) > C_6H_4(OH)COOH$, $C_6H_5COOH > C_6H_5NH_2$ (both in $CHCl_3$ and C_6H_6). Comparative study of adsorption of the individual compounds in these media reveals that the adsorption decreases in the series: $H_2O > C_6H_6 > CHCl_3$ except in the case of phenol, the order being there $H_2O > CHCl_3 > C_6H_6$—strictly the order of decreasing polarity of solvent molecules.

Modern trend of research on adsorption by activated charcoal lies in studying the importance of the polarity of solute and solvent molecules on adsorption. Work so far done in this particular line, however, shows differences both as regards actual observations and their interpretations. The more important of these discrepancies are enumerated below :

(i) According to Schilov and NeKrassov (*Z. physikal. Chem.*, 1927, 180, 65) the substitution of most radicals for hydrogen, except hydroxyl and sulphonic groups, increases the adsorption but Bartell and Miller (*J. Amer. Chem. Soc.*, 1923, 45, 1106) and Linner and Gortner (*J. Phys. Chem.*, 1935, 39, 35) are of opinion that carboxyl and NH_2 groups also like OH group decrease adsorption to a marked extent.

(ii) Contrary to the observation of Platonov, Bergman and Salman (*J. Russ. Phys. Chem. Soc.*, 1930, 62, 1975), Schilov and NeKrassov (*loc. cit.*) recorded that the *trans* form of compounds possessing a double linkage is more strongly adsorbed than the *cis* form.

(iii) Contrary to the observations of Sata and Kurano (*J. Chem. Soc. Japan,* 1932; 53, 617 ; *Kolloid Z.*, 1932, 60, 137 ; *cf.* Tamamushi, *Chem. Abs.*, 1931, 25, 5606), Jermolenko and Levina (*Acta Physicochim. U.S.S.R.*, 1939, 10, 451) as also Heymann and Boye (*Naturwissen.*, 1930, 18, 157) conclude from their results with mixed solvents that the relation between adsorption and dipole moment of the solvent is antibatic.

The present investigation was undertaken with a view to throwing light on some of these controversial points.

Experiments have been done on the following subjects :

I. The effect of different polar groups in adsorbate molecules on the adsorption keeping the solvent constant ;

    (a) adsorption of fumaric acid and maleic acid to show the effect of *cis-* and *trans-* isomers ;

(b) adsorption of acetic acid, monochloroacetic acid, glycollic acid and amino-acetic acid to show the effect of introducing chloro, hydroxyl, and amino radicals into a molecule of acetic acid ;

(c) adsorption of benzoic acid and hydroxybenzoic acid (salicylic acid) to show the effect of OH group in an acid molecule ;

(d) adsorption of phenol, benzoic acid, salicylic acid and aniline in different media to compare the effect of introducing a specific group into a benzene ring.

II. The effect of polarity of the solvent on the adsorption properties of charcoal.

Benzene has been chosen as the non-polar solvent, chloroform as moderately polar solvent having the dipole moment 1.15D ; and water as highly polar solvent having dipole moment 1.8D.

Adsorption isotherms of acetic acid, monochloroacetic acid, benzoic acid, phenol, aniline, and salicylic acid in water, chloroform and benzene media have been recorded.

EXPERIMENTAL

Preparation of Activated Charcoal.—Purest variety of sugar available in the market was charred in a silica basin and ignited at a low red heat to drive off the greater part of volatile matter. The charcoal was reduced to granules in an agate mortar, re-peatedly digested with concentrated HCl and washed at first with distilled water to free it from HCl, and then with equilibrium water till the conductivity of the wash liquid remained unaltered. It was dried and powdered in an agate mortar. Activation was effected by heating to 900° for 6 hours at pressures between 1 and 2 mm. of Hg. It was then stored free from contamination in a stoppered bottle in a vacuum desiccator containing KOH sticks.

The specific gravity of the charcoal, thus prepared, was measured by the liquid dis-placement method using benzene and the specific surface by dye adsorption method due to Paneth *et al* (*Z. physikal. Chem.*, 1922, **101**, 480 ; *Ber.*, 1924, **57**, 1215) and Bachmann and Briger (*Kolloid Z.* 1926, **39**, 342) using methylene blue. The charge on charcoal particles was determined by electroendosmotic experiments in a U-tube using platinum electrodes.

Adsorption of substances was determined by shaking in a mechanical shaker for 5-6 hours 0.5 g. of charcoal in 50 c.c. solution. It was kept overnight inside a ther-mostat maintained at 28°, filtered rapidly, rejecting the first few c.c and an aliquot part of the filtrate titrated with NaOH using suitable internal indicators. For phenols and aniline, bromide-bromate titration was used. Sörensen method (" Biochemical Labo-ratory Methods for students of the Biological Science," by C. A. Morrow and W. M. Sand-strom, 1935 Ed., p. 127 ; *cf.* Sörensen, *Biochem. Z.*, 1907, *vii*, **45**, 407) of titration adding some formaldehyde before titration was utilised in the case of the amino-acid. Adsorp-tion data have been expressed in terms of millimoles of substances adsorbed per g. of charcoal.

Nature of Charcoal.—The charcoal used had a soft velvety black appearance. The following data give an idea about its nature and characteristics ·

Ash content.	Density.	Specific surface.	Charge.
0.284%	1.58	10.5 sq. m	0

It will appear that the ash content of the sample is not so low (0.01%) as used by Miller and his co-workers (Bartell and Miller, *J. Amer. Chem. Soc.*, 1922, **44**, 1866 ; 1923, **45**, 1106) ; but in view of Kolthoff and van der Goot's observation (*Rec. trav. chim.*, 1929, **48**, 265) on samples of charcoal having ash content 1.15% and also-sample purified according to the method of Miller (*J. Phys. Chem.*, 1926, **30**, 1031) with ash content near about 0.01% the higher ash content in the former case does not appear materially to influence the nature of the adsorption isotherm and also as there is practically no reaction between the solute and the impurities in the charcoal, it is unlikely that it will affect in any way our relative and comparative measurements.

The charge of the charcoal particles, as determined by electro-osmotic experiments, is zero here. In previous works there are also references of charcoal having a negative charge (Sasaki, *J. Biochem. Japan*, 1927, **8**, 102 ; Acharya, *J. Indian Chem. Soc.*, 1936, **13**, 723), the nature and amount of charge depending mainly on the process of preparation of activated charcoal. In the face of these observations it is not unlikely that the charge due to impurity might have balanced the opposite charge due to the charcoal itself resulting in a neutral variety of charcoal in this case. From the study of adsorption of basic dyes by the negatively charged charcoal particles, Sasaki (*loc. cit.*) concludes that mass attraction between charcoal and dye molecules is the chief cause of adsorption which is undoubtedly slightly assisted by electrical attraction.

RESULTS AND DISCUSSION

Effect of Different Polar Groups in Adsorbate Molecules

(a) *Adsorption of fumaric acid and maleic acid in aqueous medium.*—The results of adsorption of fumaric and maleic acids by activated charcoal at 28° are given in Table I. c_1 denotes the initial concentration (*i.e.* concentration before adsorption), c_2, the equilibrium concentration (*i.e.* concentration after adsorption) and x/m, the millimoles of substances adsorbed per g. of charcoal.

TABLE I

	Fumaric acid			Maleic acid	
c_1	c_2	x/m	c_1	c_2	x/m
0.7485N/10	0.6630N/10	0.427	0.750N/10	0.679N/10	0.355
0.5988	0.5154	0.417	0.600	0.5324	0.338
0.4491	0.3690	0.400	0.450	0.3839	0.33
0.1994	0.2221	0.386	0.300	0.2452	0.275
0.1497	0.0874	0.311	0.150	0.1081	0.21

The results tabulated above show (on plotting) that maleic acid (the *cis* form) is less adsorbed than the fumaric acid, the *trans* form of the compound. This result while corroborating earlier observations of Schilov and NeKrassov (*loc. cit.*) and Linner and Gortner (*loc. cit.*) seems to contradict the observations of Platonov, Bergman and Salman (*loc. cit.*).

(b) *Adsorption of acetic acid, monochloroacetic acid, glycollic acid and amino-acetic acid in aqueous medium* by activated charcoal at 28° are given in the following tables and are graphically represented in Fig. 1.

TABLE II

Acetic acid			Monochloroacetic acid		
c_1	c_2	x/m	c_1	c_2	x/m
1.426 $N/10$	1.365 $N/10$	0.61	1.44 $N/10$	1.371 $N/10$	0.69
1.1408	1.084	0.56	1.152	1.085	0.67
0.8556	0.8081	0.49	0.864	0.799	0.65
0.713	0.6673	0.45	0.576	0.5187	0.573
0.5704	0.5284	0.42	0.288	0.2415	0.465
0.2852	0.2507	0.34			

TABLE III

Glycollic acid			Amino-acetic acid		
c_1	c_2	x/m	c_1	c_2	x/m
1.416 $N/10$	1.389 $N/10$	0.27	1.396 $N/10$	1.382 $N/10$	0.14
1.1328	1.106	0.268	1.1168	1.104	0.128
0.8496	0.8258	0.238	0.8376	0.8265	0.111
0.7080	0.6856	0.224	0.5584	0.5491	0.093
0.5604	0.5455	0.209	0.2792	0.2710	0.082
0.2832	0.2683	0.149			

(c) *Adsorption of benzoic acid and salicylic acid in aqueous medium* by activated charcoal at 28° are given in Table IV and is graphically represented in Fig. 2.

TABLE IV

Benzoic acid			Salicylic acid		
c_1	c_2	x/m	c_1	c_2	x/m
0.3477$N/10$	0.3055$N/10$	0.4222	1.434 $N/100$	1.166 $N/100$	0.268
0.2782	0.2384	0.3977	1.1462	0.8895	0.2657
0.2086	0.1721	0.3653	0.8604	0.6125	0.2479
0.1391	0.1031	0.3598	0.7170	0.4765	0.2405
0.0695	0.0374	0.3211	0.5731	0.3540	0.2191

Comparative study of the adsorption (Tables II, III and Fig. 1) in aqueous medium shows that the adsorption decreases in the order : $CH_2ClCOOH > CH_3COOH > CH_2(OH)COOH > CH_2(NH_2)COOH$. The introduction of a Cl group has a tendency to increase the adsorption, while both hydroxyl and amino groups decrease it, the effect of the 'amino' group being greater than hydroxyl group. Linner and Gortner (*loc. cit.*) as also Bartell and Miller (*loc. cit.*) recorded that the adsorption of succinic acid, malic acid, tartaric acid and aspartic acid decreased in the order : succinic acid>monohydroxy-succinic (malic acid)>dihydroxysuccinic (tartaric acid)>aminosuccinic acid (aspartic acid). Bartell and Miller also showed that though acetic acid was appreciably adsorbed, the adsorption of amino-acteic acid was practically nil.

Lowering of adsorption due to the introduction of a hydroxyl group is further shown in the comparative adsorption of benzoic and salicylic acid (Table IV and Fig. 2), the results being in accordance with those of Kolthoff and Van der Goot (*loc. cit.*) and Bartell and Miller (*loc. cit.*). The latter workers recorded that adsorption decreased in the series : benzoic>salicylic acid>o-aminobenzoic acid. Improvement of adsorption

Fig. 2

Curves 1-4 refer respectively to aniline in water, phenol in water, benzoic acid in water and salicylic acid in water

Equiv. conc. in N/10.

Fig. 1

Curves 1-4 refer respectively to monochloroacetic acid in water, acetic acid in water, glycollic acid in water and aminoacetic acid in water

Equiv. conc. in N/10.
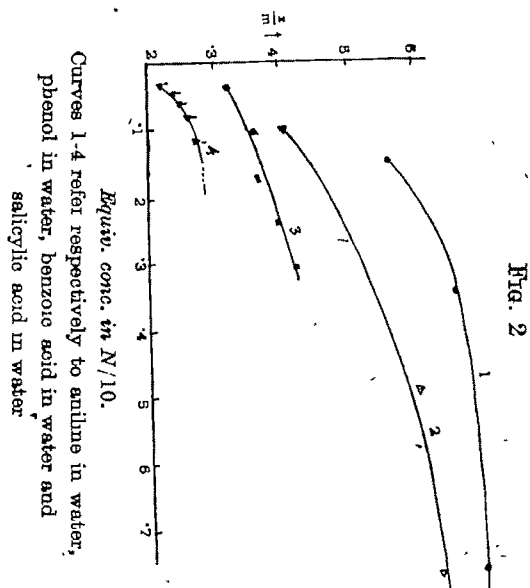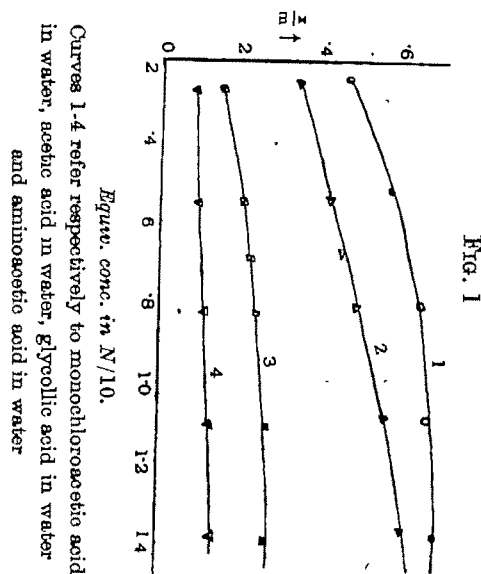
due to the introduction of a chloro group finds its indirect support in the conclusion derived by Schilov and NeKrassov (*loc. cit.*) that the substitution of most radicals except hydroxyl and sulphonic groups increases the adsorption.

(d) *Adsorption of phenol, aniline, benzoic acid and salicylic acid by activated charcoal at 28° in media having different polarities* :

TABLE V

Phenol in H_2O			Phenol in C_6H_6			Phenol in $CHCl_3$		
c_1	c_2	x/m	c_1	c_2	x/m	c_1	c_2	x/m
$1.3843N/10$	$1.314\ N/10$	0.7032	$1.34\ N/10$	$1.302\ N/10$	0.190	$0.9485N/10$	$0.9124N/10$	0.180
1.1079	1.04	0.6788	1.072	1.035	0.185	0.7588	0.7213	0.187
0.8308	0.7675	0.633	0.804	0.7947	0.05	0.5691	0.5255	0.218
0.5539	0.4933	0.6064	0.536	0.513	0.115	0.3794	0.3428	0.183
0.2770	0.2304	0.466	0.268	0.2495	0.095	0.1897	0.1676	0.110
0.1385	0.0980	0.4049						

TABLE VI

Aniline in H_2O			Aniline in C_6H_6			Aniline in $CHCl_3$		
c_1	c_2	x/m	c_1	c_2	x/m	c_1	c_2	x/m
$2.069\ N/10$	$1.996\ N/10$	0.73	$1.362\ N/10$	$1.349\ N/10$	0.06	$2.921N/10$	$2.928N/10$	..
1.6552	1.586	0.69	1.0896	1.080	0.05	2.336	2.333	..
1.2414	1.169	0.72	0.8172	0.814	0.016	1.753	1.756	..
0.8276	0.7572	0.70	0.5448	0.5555	..	1.168	1.165	..
0.4138	0.3482	0.66	0.2724	0.2727	..	0.584	0.582	..
0.2069	0.1500	0.56						

TABLE VII

Benzoic acid in H₂O	Benzoic acid in C₆H₆			Benzoic acid in CHCl₃		
	c_1	c_2	x/m	c_1	c_2	x/m
Vide Table IV	$0.484\,N/10$	$0.4645N/10$	0.0975	$0.4154N/10$	$0.3992N/10$	0.081
	0.3872	0.3687	0.0925	0.3323	0.3186	0.0685
	0.2904	0.2763	0.0705	0.2492	0.2395	0.0485
	0.0968	0.0907	0.0305	0.1662	0.1573	0.044
				0.0831	0.0782	0.0243

TABLE VIII

Salicylic acid in H₂O	Salicylic acid in C₆H₆			Salicylic acid in CHCl₃		
	c_1	c_2	x/m	c_1	c_2	x/m
Vide Table IV	$1.393\,N/100$	$1.266\,N/100$	0.064	$1.92\,N/100$	$1.811N/100$	0.054
	1.1144	0.994	0.060	1 536	1.443	0.047
	0.8358	0.7306	0.053	1.152	1.071	0.041
	0.5572	0.4811	0.038	0.768	0.6988	0.0345
	0.2786	0.2269	0.026	0.384	0.3221	0.031

(e) *Adsorption of acetic acid, monochloroacetic acid by activated charcoal at* $28°$ *in benzene media* : (For results in H₂O medium, see Table II).

TABLE IX

Acetic acid in C₆H₆			Acetic acid in CHCl₃		
c_1	c_2	x/m	c_1	c_2	x/m
$1.763\,N/10$	$1.678\,N/10$	0.43	$1\,637\,N/10$	$1.580\,N/10$	0.285
1.4104	1.322	0.44	1.3096	1.269	0.203
1.0578	0.983	0.37	0.9822	0.9436	0.193
0.7052	0.6443	0.31	0.6548	0.6180	0.179
0.3526	0.3137	0.195	0.3274	0.3028	0.123

TABLE X

Monochloracetic acid in C₆H₆			Monochloracetic acid in CHCl₃		
c_1	c_2	x/m	c_1	c_2	x/m
$1.4395N/10$	$1.354\,N/10$	0.430	$1.6662N/10$	$1.615\,N/10$	0.256
1.1576	1.077	0.373	1.1108	1.070	0.204
0.8637	0.7927	0.355	0.5554	0.5284	0.135
0.5758	0.5148	0.305	0.4443	0.4207	0.12
0.2879	0.2473	0.203	0.2222	0 2000	0.078

On plotting the tabulated results of adsorption (x/m against c_2 from Tables V-VIII) of phenol, aniline, benzoic acid and salicylic acid in water, benzene and chloroform media separately, three adsorption isotherms have been obtained showing the effect of specific grouping in the benzene ring in different media as follows :

Aniline > phenol > benzoic acid > salicylic acid in H₂O medium (Fig. 2)
Phenol ≥ salicylic acid > benzoic acid > aniline in C₆H₆ medium }
Phenol > salicylic acid > benzoic acid > aniline in CHCl₃ medium } same order

When similarly related compounds are compared, it is found that aniline is better adsorbed than phenol (*cf.* Kolthoff and Van der Goot, *loc. cit.*) and benzoic acid better than salicylic acid (*cf.* Bartell and Miller, *loc. cit.*) in aqueous medium. In non-polar benzene medium and also in moderately polar chloroform-medium, the order is just reversed.

Phenol > aniline, and salicylic acid > benzoic acid

Fig. 4

Equiv. conc. in N/10

Curves 1-4 refer respectively to acetic acid in water, in benzene and in CHCl₃.

Fig 3

Equiv. conc. in N/10

Curves 1-3 refer respectively to monochloroacetic acid in water, benzene and in chloroform.

Fig. 5

Equiv. conc. in N/10.

Curves 1-3 refer respectively to phenol in water, chloroform and in benzene.
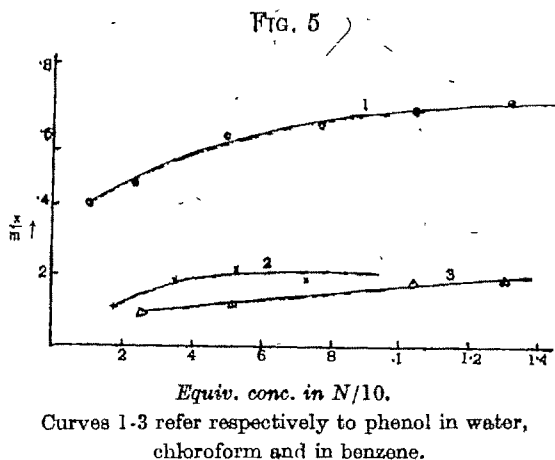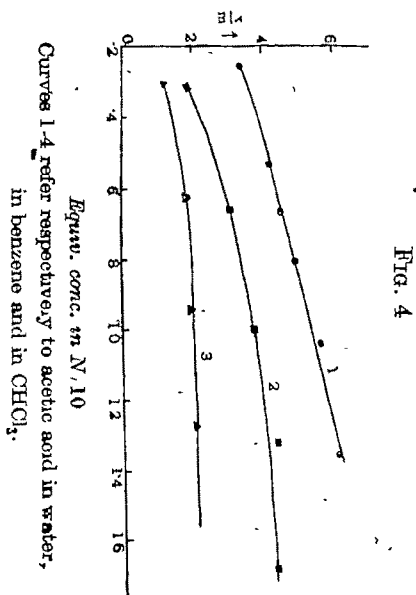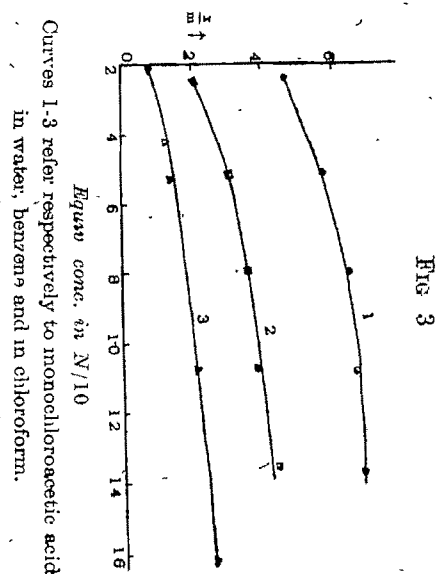
This seems to show that the more hydrophilic solute is adsorbed more strongly by charcoal in a more hydrophobic medium and *vice versa* (*cf.* Freundlich and Weller, *J. Amer. Chem. Soc.*, 1939, **61**, 2228). The marked lowering of adsorption of benzoic acid in benzene medium may also be partially attributed to its association in that medium, thereby decreasing the number of particles striking the charcoal surface at a time and increasing the size of the particles, perhaps to such an extent as may cause difficulty in their entering the ultra pores of the charcoal surface. When the adsorption of an individual compound like acetic acid (Fig. 4, Table IX), monochloroacetic acid (Fig. 3, Table X), benzoic acid (Table VII), phenol (Fig. 5, Table V), aniline (Table VI) and salicylic acid (Table VIII) in these three media is compared, a general relation holds good (except in the case of phenol) as follows : $H_2O > C_6H_6 \geq CHCl_3$. The difference in adsorption values between C_6H_6 and $CHCl_3$ as media is small in majority of cases, those in C_6H_6 being slightly greater.

The difference would have been probably still smaller, had there been no experimental error due to evaporation of the readily volatile $CHCl_3$ inspite of adequate precautions —a fact which might have raised the value of c_2, resulting in a slightly lower value for $c_1—c_2$ or x/m than the theoretical. However, neglecting the adsorption in chloroform it is found that the adsorption is greater, the greater the polarity of the solvent which is in accordance with the observations of Sata and Kurano (*loc. cit.*). Jermolenko and Levina (*loc. cit.*) and, Heymann and Boye (*loc. cit.*) however, are of opinion that the relation between adsorption and dipole moment of solvent is antibatic. The slightly lower adsorbability in chloroform medium instead of being greater, as was expected, than that in benzene medium may be explained on the basis that in this parti-cular case, perhaps, the secondary factors like lowering of surface tension and solubility (Freundlich, *Z. physikal. Chem.*, 1906, **57**, 385 ; Santa, *Kolloid Z.*, 1929, **49**, 275 ; de Izagrure, "Colloid and Capillary Chemistry", *Eng. Ed.*, 1926, 817) which affect the ad-sorption are so prominent as to overshadow the single primary effect of polarity of the solvent. If, however, the adsorption isotherms of compounds in chloroform and benzene media only are compared, the antibatic relation as obtained by Heymann and Boye, and Jermolenko and Levina seems to hold good. Extensive work in this line can only settle these controversial points.

Conclusion

1. Fumaric acid (*trans* form) is better adsorbed than maleic acid (*cis* form).

2. Introduction of a hydroxyl group decreases the adsorption. Amino group affects the adsorption in the same way but to a greater extent. Chloro group has a tendency to increase the adsorption as is evident from the following series :

Benzoic acid>salicylic acid

chloro-acetic acid>acetic acid>glycollic acid>amino-acetic acid (effect of introducing chloro, hydroxyl and amino group to a molecule of acetic acid).

3. Adsorption isotherms of benzoic acid, salicylic acid, phenol and aniline have been compared to show the effect of specific grouping in a benzene ring. Polar influence of the solvent has been studied by using solvents like benzene, chloroform and water.

H_2O medium—aniline>phenol>benzoic acid>salicylic acid

$CHCl_3$,, —phenol≥salicylic acid>benzoic acid>aniline (practically zero)

C_6H_6 ,, —phenol>salicylic acid>benzoic acid>aniline

When the adsorption of an individual compound in these three media is compared, a general regularity holds good except in the case of phenol in that the adsorption de-creases in the series : $H_2O>C_6H_6>CHCl_3$. Only in the case of phenol the relation is $H_2O>CHCl_3>C_6H_6$ which is strictly the order of decreasing polarity.

Our best thanks are due to Prof. J. N. Mukherjee, C.B.E., D.Sc., F.N.I., for his keen interest and helpful suggestion, and for providing us with the necessary research facilities.

ABSORPTION OF IODINE BY HYDROXYLAMINE SALTS. PART I. STUDY OF THE REACTION

BY R. K. TRIVEDI, C. C. SHAH AND D. K. PATEL

In the reaction of iodine with hydroxylamine it appears that at least two types of reactions proceed simultaneously, one involving absorption and the other, liberation of iodine. Titrations show that the amount of iodine absorbed always reaches a maximum after which the absorption distinctly diminishes. In neutral solution, the liberation of iodine takes place slowly and apparently reaches a definite value in fifteen to thirty minutes. Nitrite appears to be the chief product of the reaction. This is supported by the fact that the maximum amount of iodine absorbed tends to approximate to four atoms of iodine for one molecule of hydroxylamine and never exceeds this limit.

Although various investigations (Meyeringh, *Ber.*, 1877, **10**, 1940 ; Haga, *J. Chem. Soc.*, 1887, **51**, 794 ; Jones and Carpenter, *ibid.*, 1903, **83**, 1394 ; Erwin, Rupp and Mader, *Arch. Phar.*, 1913, **251**, 295 ; Bray, Simpson and Mackenzie, *J. Amer. Chem. Soc.*, 1919, **41**, 1363 ; Raschig, " Schwefel-und-stickstoff studien ", 1924, p. 183 ; Olander, *Z. physikal. Chem.*, 1927, **129**, 1) have tried to work out a suitable method for the volumetric estimation of hydroxylamine based on the absorption of iodine, neither a satisfactory standard method has been evolved nor does the course of the reaction appear to have been studied. Meyeringh (*loc. cit.*) represented the reaction involved as

$$2NH_2OH + 2I_2 = N_2O + H_2O + 4HI$$
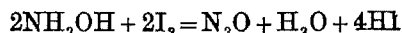
Haga (*loc. cit.*), however, reported that the above method was unsatisfactory, because the amount of iodine absorbed was found to depend on (*i*) the concentration of the solution, (*ii*) the presence of the sodium salts and (*iii*) the presence of carbonic anhydride. Jones and Carpenter (*loc. cit.*) state " in basic solutions about three atoms of iodine were required for one molecule of hydroxylamine." According to Erwin, Rupp and Mader (*loc. cit.*) the quantity of iodine absorbed depends on (*i*) the nature and the quantity of the material used to absorb hydriodic acid and (*ii*) the time during which the reaction mixture is allowed to stand. Bray, Simpson and Mackenzie (*loc. cit*) suggested an empirical method. Endress and Kaufmann (*Annalen*, 1937, **530**, 184) have evolved a method for a micro-estimation of hydroxylamine in concentrations of 0.1 to 0.2 × 10^{-6} g. of NH_2OH in 10 c.c., the HNO_2 formed may then be determined photometrically by the diazo method, the error being ± 2 to 3 %.

When the absorption of iodine by hydroxylamine is measured, the results widely vary being governed by (*i*) the time of reaction, (*ii*) temperature and (*iii*) the acidity of the solution. When a neutral solution of hydroxylamine salt is oxidised by means of iodine, nitrite seems to be the main product of reaction, though nitrate is also detected in minute traces. The reaction appears to take place in two stages :—

$$NH_2OH + O_2 = HNO_2 + H_2O \qquad \cdots \ (1)$$

$$HNO_2 + O = HNO_3 \qquad \cdots \ (2)$$

As the nitrate is found to be present only in traces, it is reasonable to assume that the final product of oxidation of hydroxylamine by iodine can be nitrous acid only. The

presence of traces of nitrate may be due to the oxidation of nitrous acid by atmospheric oxygen or it may have been formed by auto-oxidation thus :

$$3HNO_2 = 2NO + HNO_3 + H_2O \qquad \qquad .. \quad (3)$$
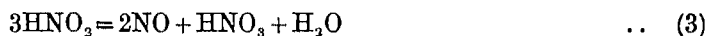
Primary and Secondary Reactions.—When titrations were carried out under different experimental conditions, the quantity of iodine absorbed was found to vary considerably with (*i*) concentration of the hydroxylamine salt, (*ii*) quantity of iodine added, (*iii*) temperature and (*iv*) time, although the quantity of hydroxylamine taken remained the same. It has been shown in what follows that in the oxidation of hydroxylamine, there must be at least two types of reactions going on simultaneously, once the reaction has started. It appears that in the beginning the primary reactions, shown by the following equations :

$$NH_2OH + I_2 = 2HI + HNO \text{ and } 2HNO = H_2O + N_2O \qquad \qquad .. \quad (4)$$

$$NH_2OH + 2I_2 + H_2O = HNO_2 + 4HI \qquad \qquad .. \quad (5)$$

$$NH_2OH + 3I_2 + 2H_2O = HNO_3 + 6HI \qquad \qquad .. \quad (6)$$
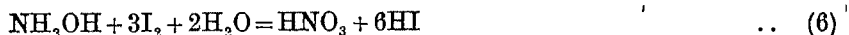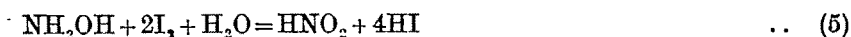
are faster than the secondary reactions shown by the following equations :

$$2HNO_2 + 2HI = 2H_2O + 2NO + I_2 \qquad \qquad .. \quad (7)$$

$$4HI + O_2 = 2H_2O + 2I_2 \qquad \qquad .. \quad (8)$$
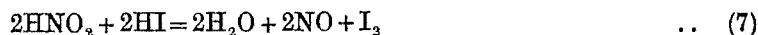
It can be seen that during secondary reactions iodine is liberated, while during primary reactions iodine is absorbed.

Effect of Time.—From Table I it appears that the amount of iodine absorbed always reached a maximum in about 2 to 10 minutes in neutral solutions showing that up to this point iodine was being absorbed. After the maximum was reached the secondary reactions set in and the amount of iodine absrobed decreased with increase in time until in about 30 minutes the speed of the two reactions was almost the same, except that the secondary reactions preponderated to a small extent.

TABLE I

Vol. of $N/100$ iodine soln. absorbed at 35° by 5 c.c. soln. of $M/100$-NH$_2$OH.HCl at different dilutions with respect to time when 25 c.c. of $N/100$ iodine solution were added every time.

Time.		Dilution		Time.		Dilution	
	50 c.c.	200 c.c.	500 c.c.		50 c.c.	200 c.c.	500 c.c.
1 min.	9.75 c.c.	14.0 c.c.	17.3 c.c.	10 min.	6.90 c.c.	17.6 c.c.	19.4 c.c.
3	10.40	17.0	19.3	15	6.40	17.1	19.3
5	9.40	17.9	19.5	30	6.00	16.0	19.3

Similar results were obtained with hydroxylamine sulphate and hydroxylamine nitrate under the above experimental conditions.

Effect of Dilution on the Absorption of Iodine.—In neutral solution the amount of iodine absorbed went on increasing as the dilution was increased up to a certain limit as shown in Table II.

TABLE II

Vol. of $N/100$ iodine soln. absorbed at 35° by 5 c.c. soln. of hydroxylamine salts in 5 minutes at different dilutions when 25 c.c. of $N/100$ iodine solution were added every time.

Dilution.	NH$_2$OH.HCl $M/100$	(NH$_2$OH)$_2$. H$_2$SO$_4$ $M/200$	NH$_2$OH. HNO$_3$ $M/100$	Dilution.	NH$_2$OH.HCl $M/100$	(NH$_2$OH)$_2$. H$_2$SO$_4$ $M/200$	NH$_2$OH. HNO$_3$ $M/100$
10 c.c.	6.4 c.c.	7.1 c.c.	6.85 c.c.	350 c.c.	19.4 c.c.	18.35 c.c.	18.35 c.c.
25	6.7	7.2	7.05	500	19.5	18.90	19.25
50	9.4	10.4	9.20	750	20.0	20.00	19.80
100	17.9	14.15	14.30	1000	20.0	20.00	20.00
200	19.3	17.95	17.65				

A maximum absorption of iodine occurred with a concentration of 1/50 mol. per litre, at 1/320 mol. per litre and at 1/200 mol. per litre respectively for hydroxylamine hydrochloride, sulphate and nitrate as shown above.

Effect of the amount of Iodine on its Absorption.—In neutral solution as shown in Table III, though the amount of iodine absorbed increased as the quantity of iodine initially added was increased, the amount of iodine absorbed became constant when the quantity of iodine initially added was twice the maximum absorption.

TABLE III

Vol. of $N/100$ iodine soln. absorbed at 35° by 5 c.c. soln. of hydroxylamine salts in 5 minutes at 200 c.c. dilution when different amounts of iodine soln. were added every time.

Vol. of $N/100$-I$_2$ soln.	NH$_2$OH. HCl $M/100$	(NH$_2$OH)$_2$ H$_2$SO$_4$ $M/200$	NH$_2$OH. HNO$_3$ $M/100$	Vol. of $N/100$-I$_2$ soln.	NH$_2$OH. HCl $M/100$	(NH$_2$OH)$_2$ H$_2$SO$_4$ $M/200$	NH$_2$OH. HNO$_3$ $M/100$
5 c.c.	5.0 c.c.	5.00 c.c.	5.00 c.c.	25 c.c.	17.7 c.c.	17.95 c.c.	17.65 c.c.
10	10.0	10.00	10.00	35	17.9	17.95	17.90
20	16.8	17.00	16.85	50	17.9	18.95	17.90

Effect of Temperature on the Reaction.—The rate of reaction increased with rise in temperature and *vice versa.* At 45° it was almost three times the quantity absorbed at 0°. It was not possible to continue the observations given below in Table IV, as above this temperature losses due to volatilisation of iodine became appreciable and anomalous results were obtained.

TABLE IV

Vol. of $N/100$ iodine soln. absorbed at different temp. by 5 c.c. soln. of hydroxylamine salts in 5 minutes at 200 c.c. dilution when 25 c.c. of $N/100$ iodine soln. were added every time.

Temp.	NH$_2$OH. HCl $M/100$	(NH$_2$OH)$_2$. H$_2$SO$_4$ $M/200$	NH$_2$OH. HNO$_3$ $M/100$	Temp.	NH$_2$OH. HCl $M/100$	(NH$_2$OH)$_2$. H$_2$SO$_4$ $M/200$	NH$_2$OH. HNO$_3$ $M/100$
5°	8.6 c.c.	8.95 c.c.	5.60 c.c.	35°	17.7 c.c.	17.95 c.c.	17.65 c.c.
15	11.4	12.95	13.65	45	18.3	18.55	18.00
25	15.7	17.10	16.40				

All reactions were carried out at a constant temperature in 500 c.c. glass stoppered bottles which were kept in a constant temperature ($\pm 0.1°$) water-bath fitted with an electric thermo-regulator and a stirrer. An excess of iodine was added to the hydroxylamine salt solution and the excess of free iodine was titrated back with standard sodium thiosulphate solution.

Detection and Estimation of the Products of Reactions.—Nitrites were detected with Griess reagent. Traces of nitrates were detected with phenoldisulphonic acid test colorimetrically. Hydroxylamine salt solution (5 c.c.) gave nitrite as shown below when estimated colorimetrically by Griess reagent method (diazo method).

TABLE V

Salt	Conc. per litre	Nitrite obs.	Nitrite reqd. as per sqn.
$NH_2OH.HCl$	1/150 M	1.49 mg.	1.53 mg.
$(NH_2OH)_2.H_2SO_4$	1/320	1.41	1.44
$NH_2OH.HNO_3$	1/200	1.12	1.15

The hydroxylamine nitrate required for this work was prepared by the method of Lossen (Mellor, "Treatise on Theoretical and Inorganic Chemistry" Vol. VIII, p. 303). Berthelot and Andrew (*Compt. rend.*, 1890, 11, 95) tried to prepare hydroxylamine nitrate by double decomposition but could obtain only a viscid liquid. The solution was concentrated over phosphorous pentoxide in a vacuum desiccator. The viscid liquid so obtained when cooled in a freezing mixture gave a white crystalline solid which was kept in a desiccator over phosphorous pentoxide. It is a white crystalline substance, extremely hygroscopic and decomposes spontaneously, more so under reduced pressure.

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EXPERIMENTS ON THE SYNTHESIS OF OREOSELONE. PART I.

By Satyendra Kumar, Labhu Ram and Jnanendra Nath Ray

Fries migration of *iso*valeroyloxy-7-hydroxycoumarin gives largely 8-acyl derivative. β-Resorcylic acid, on condensation with malic acid, gives 7-hydroxycoumarin-6-carboxylic acid and 5-hydroxycoumarin-6-carboxylic acid which can be separated after methylation. 7-Hydroxycoumarin-6-carboxylic chloride condenses with ethyl *iso*propyl malonate and ethyl *iso*propyl cyanacetate but the products resist ring-closure to a coumaranone.

Spàth, Klager and Schlosser (*Ber.*, 1931, **64**, 2203) published a preliminary investigation on oreoselone, a fish poison. In a later paper (*ibid.*, 1933, **66**, 749) the structure (I) was advanced on the basis of its degradation to 7-hydroxycoumarin.

(I)
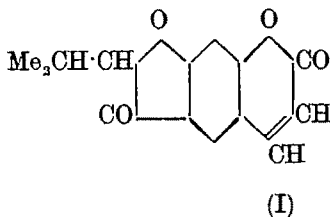
Therefore, oreoselone belongs to the psoralene group, of furocoumarins.

Yamashita (*Sci. Repts. Tohoku Imp. Univ.*, 1935, **24**, 205) prepared 2-*iso*propyl-6-hydroxycoumaranone but could not transform it to oreoselone. We have also failed to convert 6-hydroxycoumaranone to a coumarin with malic acid.

Therefore we directed our attention to the Fries migration of 7-*iso*valeroyloxycoumarin (II, R=H). The product is 7-hydroxy-8-*iso*valeroylcoumarin.

(II)   (III)
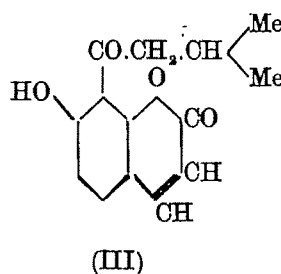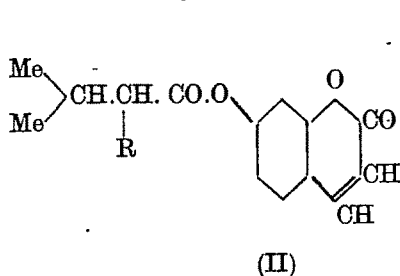
Minute amounts of 6-acyl derivative were also formed. Fries migration of 7-ω-chloro-*iso*valeroyloxycoumarin (II, R=Cl) was not successful (*cf.* however, Row and Seshadri *Proc. Ind. Acad. Sci.*, 1940, **11A**, 206 who synthesised coumarino-7 : 8-furanones by the Fries migration of the chloroacetyl derivative).

Clayton (*J. Chem. Soc.*, 1908, **93**. 525) found that carboxy, carbomethoxy and aceto group in the 4-position of the resorcinol molecule inhibited Pechmann condensation. But Shah, Sethna, Banerjee and Chakravarti. (*J. Indian Chem. Soc.*, 1937, **14**, 714) found that methyl β-resorcylate reacted with ethyl acetoacetate. They confirmed that 4-acyl group inhibited the reaction. 7-Hydroxycoumarin-6-carboxylic acid (*cf.* Arama,

Bull. Chem. Soc., Japan, 1924, **4**, 113), as prepared from β-resorcylic acid, is accompanied by small quantities of an isomeric substance. The two have been separated after methylation. From the completely methylated product, 7-methoxy-6-carbomethoxycoumarin (m.p. 172°) is easily isolated. From the mother-liquors an isomeric product (m.p. 121-22°) is obtained. This substance on demethylation gives an acid (violet ferric reaction) which on decarboxylation furnishes 5-hydroxycoumarin. Hence this isomeric product is 5-hydroxy-6-carboxycoumarin (VI). This is reminiscent of the observation of Sethna, Shah and Shah (*J. Chem. Soc.*, 1938, 228) who found methyl β-resorcylate to give 5-hydroxy-6-carbomethoxycoumarin derivatives when anhydrous aluminium chloride was used in anhydrous-ether. Therefore, it appears that aluminium chloride is not peculiar in that it induces only this type of condensation and in the formulation of any theory regarding the formation of 5-hydroxycoumarins by aluminium chloride, this fact has to be taken into account.

7-Hydroxycoumarin-6-carboxylic acid has been converted into 7-methoxycoumarin-6-carboxylic acid. The acid chloride of the latter (V) reacts with ethyl sodio-*iso*propyl malonate under pressure to give (IV, R = CO₂Et),

(IV)   (V)   (VI)
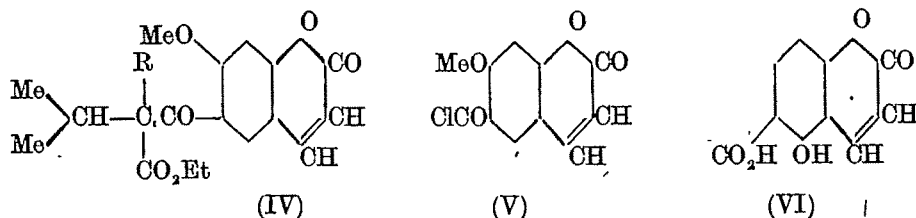
but the substance could not be hydrolysed smoothly. All attempts to hydrolyse it resulted in its breakdown to 7-hydroxy-6-carboxycoumarin.

4-Cyanacetoresorcinol dimethyl ether (Sonn, *Ber.*, 1918, **51**, 823) is smoothly converted into 6-methoxycoumaranone (Blom and Tambor, *Ber.*, 1905, **38**, 3590) by the elimination of methyl cyanide but the condensation product of ethyl *iso*propylcyanacetate with the chloride of 7-methoxycoumarin-6-carboxylic acid (IV, R = CN) does not give an analogous coumaranone, a complex substance being formed. The product (IV, R = CN) could not also be satisfactorily demethylated.

The compound (V) reacts with *iso*butyl zinc iodide and a product (m.p. 87-89°) is obtained which does not analyse for the expected ketone. This substance may be slightly impure *iso*butyl ester (m.p. 99-101°) mixed with which it has m.p. 87-90° and with which its analytical results correspond.

EXPERIMENTAL

2-*Hydroxy-4-methoxyphenylisobutyl Ketone.*—To a solution of resorcinol dimethyl ether (12.8 c.c.) in carbon bisulphide (12.8 c.c.) powdered aluminium chloride (10.5 g) was added. *iso*Valeroyl chloride (14.8 o c.), dissolved in carbon bisulphide (12 c.c.), was added gradually with shaking. The mixture was ultimately refluxed till the evolution of hydrogen chloride ceased. After removal of the solvent the reaction mixture was decomposed with ice and extracted with ether. The product has b.p. 165°/4 mm., yield 60%.

The *phenylhydrazone* crystallised from dilute alcohol in fine needles, m.p. 85°. .(Found : N, 9.32. $C_{18}H_{22}O_2N_2$ requires N, 9.39 per cent).

Bromination of the above ketone in acetic acid solution furnished an oil which, when boiled with sodium acetate in alcoholic solution, gave a product, m.p. 113° after crystallisation from acetic acid. This substance (Found : C, 43.21 ; H, 5.43 per cent) was not a coumaranone.

Methylation of 2-Hydroxy-4-methoxyphenylisobutyl Ketone in acetone solution with Dimethyl Sulphate.—A mixture of the ketone (26 g.) dissolved in acetone (90 c.c.) and anhydrous potassium carbonate (50 g.) was refluxed on the steam-bath with dimethyl sulphate (21 c.c.) for 4 hours. After addition of water, the semi-solid product was stirred with dilute alcohol when it solidified. After crystallisation from alcohol it had m.p. 145-46°. (Found,: C, 71.7 ; H, 8.03 per cent). It is the condensation product of 2 mols. of the methylated ketone with 1 mol. of acetone and has the structure

$$(2:4) \ (MeO)_2.C_6H_3CO.CH.CH.Me_2$$
$$|$$
$$CMe_2$$
$$|$$
$$(2:4).(MeO)_2.C_6H_3.CO.CH.CH.Me_2$$
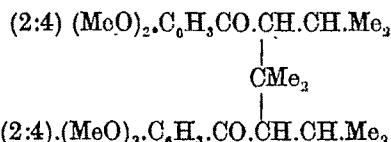
Condensation of Benzoylglycollonitrile with Resorcinol : Formation of ω-Benzoyloxy-resacetophenone.—To an ice-cold mixture of benzoylglycollonitrile (5.8 g.), resorcinol (4 g.), zinc chloride (7.7 g.), dry ether (40 c.c.), a stream of dry hydrogen chloride was passed till the originally separated oily layer solidified. After standing in an ice-bath for 12 hours, the mixture was decomposed and ether distilled off. After heating with water, the product was collected and crystallised from alcohol, m.p. 200°, yield 6.2 g. (Found : C, 66.13 ; H, 4.38. $C_{15}H_{12}O_5$ requires C, 66.18 ; H, 4.41 per cent).

ω-Benzoyloxyresacetophenone did not condense with ethyl acetoacetate or malic acid under the usual conditions.

6-Methoxycoumaranone (Blom and Tambor, *loc. cit.*) could not be alkylated with *iso*propyl iodide in the presence of sodium ethoxide or sodamide.

6-Methoxycoumaranone (1 g.) in acetone (10 c.c.) was refluxed with potassium hydroxide solution (5 c.c. of 5%) for 10 minutes. The product separated and was crystallised from hot benzene, m.p. 210°. (Found : C, 68.18 ; H, 5.67. $C_{21}H_{20}O_6$ requires C, 68.48 ; H, 5.43 per cent). This is obviously the condensation product of two molecules of the coumaranone with one of acetone. Similarly ethylmethyl ketone gave a condensation product, m.p. 195° after crystallisation from benzene. (Found : C, 69.1 ; H, 5.76. $C_{22}H_{22}O_6$ requires C, 68.81 ; H, 6.17 per cent). The condensation with aromatic aldehydes was monomolecular ; *benzylidene*, m.p. 145° (Found : C, 75.93 ; H, 5.23. Calc. C, 76.19 ; H, 4.76 per cent) ; *piperonylidene*, m.p. 187° (Found : C, 68.8 ; H, 4.37. $C_{17}H_{12}O_5$ requires C, 68.9 ; H, 4.05 per cent) ; *veratrylidene*, m.p. 185° (Found : C, 69.43 ; H, 5.23. $C_{18}H_{16}O_5$ requires C, 69.23 ; H, 5.12 per cent) ; *o-nitrobenzylidene*, m.p. 199-200° (Found : N, 5.01. $C_{16}H_{11}O_5N$ requires N, 4.71 per cent) ; *6-nitropiperonylidene*, m.p. 250° (decomp.). (Found : N, 4.09. $C_{17}H_{11}O_7N$ requires N, 4.06 per cent). 6-Methoxycoumaranones were prepared with either aqueous sodium hydroxide solution or with a few drops of concentrated hydrochloric acid.

Fries Migration of 7-iso *ValeroyloxycoumarIn* : *Formation of* 7-*Hydroxy-8-*
isovalerocoumarin.—A solution of 7-hydroxycoumarin (1 g.) in pyridine (0.6 c.c.) (dis-
solved by warming) was treated dropwise in the ice-cold with *iso*valeryl chloride (1 c.c.).
The mixture was finally warmed for 5 minutes with stirring. After decomposition with
ice, the precipitated solids (after drying) were crystallised from petroleum ether, m.p.
68°. (Found : C, 68.29 ; H, 5.79. $C_{14}H_{11}O_4$ requires C, 68.29 ; H, 5.69 per cent).
The foregoing 7-*iso*valeroyloxycoumarin (33 g.) and powdered aluminium chloride (7.5 g.)
were heated for 45 minutes at 70-75°, for 45 minutes at 120° and finally for 30 minutes
at 135°. After decomposition with ice, the residue was extracted with ether. From
the ethereal solution the ketone formed was recovered. The product crystallised from
50% alcohol (oxime, m.p. 168°). (Found : C, 68.53 ; H, 5.69. $C_{14}H_{14}O_4$ requires C,
68.29 ; H, 5.69 per cent). The *acetyl* derivative of the ketone had m.p. 93° after crys-
tallisation from petroleum ether. (Found : C, 67.0 ; H, 5.59. $C_{16}H_{16}O_5$ requires
C, 66.67 ; H, 5.55 per cent). The ketone did not give any colour with ferric chloride
and hence was concluded to be the 8-*iso*valero derivative (*cf.* Ray, Silooja and Vaid, *J.*
Chem. Soc., 1935, 813).

α-Chloro*iso*valeroyl derivative of 7-hydroxycoumarin, prepared in the usual way,
had m.p. 77° (ex. petroleum ether). (Found : C, 60.29 ; H, 4.77. $C_{14}H_{13}O_4Cl$ requires
C, 59.89 ; H, 4.63 per cent). Fries migration of this substance was not successful under
all conditions tried.

7-Hydroxycoumarin-6-carboxylic Acid.—The following modification gave double the
yield obtained by Arama (*loc. cit.*). Concentrated sulphuric acid (10 c.c.) was added to a
mixture of β-resorcylic acid (5 g.), malic acid (4.5 g.) and the mixture left overnight.
After heating at 110° for 3-4 hours, it was poured on to crushed ice when a pasty mass
separated which , however, solidified on scratching. After crystallisation from alcohol
the mixture had m.p. 265-72°. Arama (*loc. cit.*) gives m.p. 244-62° depending on
the rate of heating. The mixture, m.p. 265-72°, (3 g.) dissolved in dry acetone (100 c.c.)
was mixed with potassium carbonate (anhydrous, 12 g.) and treated with dimethyl sul-
phate (purified, 6 c.c.) in small quantities at a time, the whole thing being kept under
reflux. An intense yellow colour developed after a short interval and as the methylation
proceeded, it became fainter and fainter and ultimately disappeared, the whole operation
taking about 4-5 hours. After removal of acetone by distillation, water was added and
the residue collected. It was crystallised from alcohol when the first crop, m.p. 172°,
(yield 1.5 g.) separated. (Found : C, 61.47 ; H, 4.34. $C_{12}H_{10}O_5$ requires C, 61.54 ; H,
4.27 per cent). The alcoholic mother-liquor was completely evaporated and the residue
repeatedly extracted with petroleum ether whence a mixture, m.p. 95°-100°, was ob-
tained. After crystallisation from dilute alcohol (twice) and four successive crystallisa-
tions from hot petroleum ether, a substance, m.p. 121°-22° (0.03 g.) was obtained. (Found
C, 61.15 ; H, 4.65. $C_{12}H_{10}O_5$ requires C, 61.54 ; H, 4.27 per cent). The foregoing
methylmethoxycoumarin carboxylate (0.4 g.) was heated for a few seconds with con-
centrated sulphuric acid (3.5 c.c.), the colour of the solution changed from yellowish green
to brownish green. After cooling, the solution was decomposed by pouring over crushed
ice. The separated solids crystallised from hot dilute alcohol, m.p. 251-52°. (Found :
C, 58.40 ; H, 3.3. $C_{10}H_6O_5$ requires C, 58.25 ; H, 2.9 per cent). The substance gave

(a) deep violet colour with ferric chloride, (b) decomposed sodium bicarbonate and (c) an ice-cold dilute solution in sodium hydroxide showed a yellowish green fluorescence which faded very quickly (cf. 7-hydroxycoumarain -6-carboxylic acid which gave deep blue fluorescence under the same conditions). .

The foregoing acid (0.6 g.) was heated in an oil-bath at 260° for 4-5 hours. The product was treated with very dilute solution of sodium bicarbonate, washed and the residue crystallised from alcohol, m.p. 225°. It was identified as 5-hydroxycoumarin by mixed m.p. with an authentic specimen. Therefore the methoxymethyl ester, m.p. 121-22°, was 5-methoxy-6-carbomethoxycoumarin.

·7-*Methoxycoumarin*-6-*carboxylic Acid*.—The methoxy methyl ester, m.p. 172° (0.5 g.) was heated with sodium hydroxide solution (7 c.c. of 10%) till complete solution was obtained. After cooling in ice, the solution was acidified with excess of hydrochloric acid and the mixture boiled for a few minutes. The precipitate was crystallised from acetic acid, m.p. 274°. (Found : C, 60.36 ; H, 3.4. $C_{11}H_8O_5$ requires C, 60.0 ; H, 3.69 per cent).

The *chloride* of the above acid (4 g.) was prepared with thionyl chloride (80 c.c.) by heating for 1 hour. After removal of the unreacted thionyl chloride in *vacuo*, the residue crystallised from hot dry toluene, m.p. 190-91°. (Found : C, 56.68 ; H, 3.59. $C_{11}H_7O_4Cl$ requires C, 55.46 ; H, 2 94 per cent). Ethyl ester prepared after interaction of the chloride with alcohol had m. p. 147-48°. (Found : C, 63.06 ; H, 5.18. $C_{13}H_{12}O_5$ requires C, 62.9 ; H, 4.84 per cent). The *amide* had m.p. 297-98° after crystallisation from 33% alcohol. (Found : N, 6.52. $C_{11}H_9O_4N$ requires N, 6.39 per cent).

Condensation of 7 - Methoxycoumarin - 6 - carboxylic Chloride with Sodioethylisopropyl Malonate : `Formation of` (IV, R=$COOC_2H_5$).—Sodio ethyl*iso*propyl malonate prepared in dry toluene (2.1 g. ethyl*iso*propyl malonate, sodium powder 2.5 g.) was heated with the acid chloride (2.4 g.) at 115-120° under pressure for 4-5 hours. The precipitated solids were found to be a mixture of sodium chloride and sodium salt of 7-methoxycoumarin-6-carboxylic acid formed by hydrolysis. The toluene filtrate gave a solid on removal of the solvent. After repeated washing with petroleum ether, the substance was crystallised from alcohol, m.p. 141-42°. (Found : C, 62.4, 63.0 ; H, 4.83, 5.6. $C_{21}H_{24}O_8$ requires C, 62.37 ; H, 5.94 per cent). The above substance could not be hydrolysed to the related dicarboxylic (or a monocarboxylic) acid as it hydrolysed to 7-methoxycoumarin-6-carboxylic acid.

The similar condensation with ethyl-sodio a-bromomalonate gave two substances of unknown constitution which were separated by the solubility of one in petroleum ether. The petroleum ether-soluble substance crystallised from dilute acetic acid and had m.p. 55°. (Found : C, 53.38 ; H, 6.29 per cent.). From the insoluble portion, hot carbon tetrachloride removed the other product which had m.p. 140°, after crystallisation from alcohol. (Found : C, 62.42 ; H, 4.94 per cent). The nature of these products is still under investigation.

Since ω-cyanoacetate resacetophenone dimethyl ether (Sonn, *Ber.*, 1918, **51**, 823) (2 g.) was smoothly converted by demethylation and elimination of hydrogen cyanide (or by the elimination of acetonitrile) at room temperature (30°), when dissolved in sulphuric acid (10 c.c.) and left for 2 hours, into 6-methoxycoumaranone, the possibility of

similar ring-closure in IV (R=CN) was investigated. The condensation of ethyl *iso*propyl cyanacetate and the chloride of 7-methoxycoumarin-6-carboxylic acid was carried out as described in the case of *iso*propyl malonic ester derivative with the difference that the temperature was maintained at 130°. The residue from toluene was crystallised from alcohol and had m.p. 156°. [Found : C, 64.25 ; H, 5.37 ; N, 3.98. $C_{19}H_{19}O_6N$ (IV, R=CN) requires C, 63.86 ; H, 5.32 ; N, 3.92 per cent]. The substance (1 g.) in sulphuric acid (5 c.c.), left for 12 hours at room temperature and then for 2 hours at 40-50° gave a substance after decomposition with ice which crystallised from hot benzene and had m.p. 258-60°. (Found : C, 59.79 ; H, 3.99 per cent). This substance is not the coumaranone derivative expected. It degraded to 7-methoxycoumarin-6-carboxylic acid when treated with ammoniacal silver nitrate.

Reaction of the Chloride of 7-Methoxycoumarin-6-carboxylic Acid with iso*Butyl Zinc iodide.*—The acid chloride (6 g) suspended in dry toluene (10 g.) was treated with *iso*butyl zinc iodide (prepared from 15 g. of *iso*butyl iodide) in toluene. After standing in ice for 2 hours and then at room temperature (30°) for 1½ hours, the mixture was decomposed with ice and hydrochloric acid. The residue from toluene was washed free from 7-methoxycoumarin-6-carboxylic acid with sodium bicarbonate solution and was treated with ether. The ethereal solution furnished a product which after crystallisation from petroleum ether had m.p. 87-89°. (Found : C, 65.49 ; H, 6.2. $C_{15}H_{16}O_5$ requires C, 65.21 ; H, 5.8 per cent). A mixed m.p. with an authentic specimen of *iso*butyl ester of 7-methoxycoumarin-6-carboxylic acid (m.p. 99-101°) was 87-90°.

Our thanks are due to Dr. K. N. Gaind for his assistance in the experimental work.

EXPERIMENTS ON THE SYNTHESIS OF OREOSELONE. PART II.

BY KEDAR NATH GAIND, INDER SAIN GUPTA, JNANENDRA NATH RAY AND
KUNTI NANDAN SAREEN

ω-Chlororesacetophenone condenses with ethyl acetoacetate to give 6-chloroacetyl-7-hydroxycoumarin which is transformed to the related furanocoumarin. But alkylation of this substance proved difficult. It, however, condenses with acetone to give a monomolecular condensation product. ω-Chlororesacetophenone also condenses with oxaloacetic ester and the product has been converted into the related furanocoumarin and condensed with acetone.

Clayton (*J. Chem. Soc.*, 1908, **93**, 2016) found that a nitro, carboxyl, carbethoxyl and acetyl group in the *meta* position of a phenol molecule prevented Pechmann reaction taking place with a β-ketonic ester although Shah, Sethna, Bannerjee and Chakravarti (*J. Indian Chem. Soc.*, 1937, **14**, 714) found that β-methyl resorcylate condensed with ethyl acetoacetate. It has been found that β-resorcylic acid condensed with malic acid (Part I, *J. Indian Chem. Soc.*, 1946, 23365) to give simultaneously a 7-hydroxy- and a 5-hydroxycoumarin derivative. It has now been found that ω-chlororesacetophenone condenses with ethyl acetoacetate to give (I, R=Me) in poor yield. The condensation

HO   O   R₁CH   O   O   Me   O   O
      CO   R₁CH   CO   Me C=C   CO
      CH   OC   CH   Me CO   CH
ClCH₂.OC   CR   CR   CR

(I)   (II)   (III)
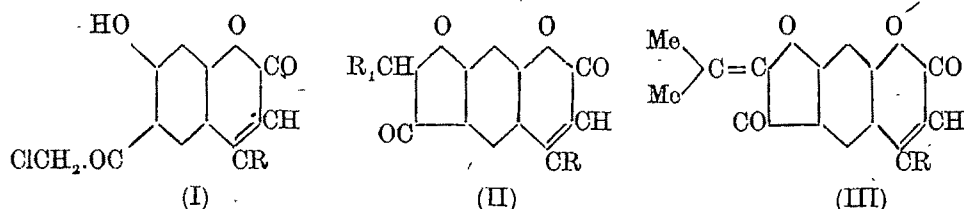
takes place in presence of both sulphuric acid and alcoholic hydrogen chloride. The substance (I, R=Me) can be converted difficultly into coumaranone (II, R=Me ; R_1=H) in dioxane solution. But the introduction of *iso*propyl group in (II, R_1=H ; R=Me) is not possible on account of the ease with which its sodio derivative decomposes. The substance (II, R_1=H ; R=Me), however, condenses with acetone to give (III, R=Me). Shriver and Anderson (*J. Amer. Chem. Soc.*, 1938, **60**, 1416) found 6-methoxycoumaranone to condense with acetone unimolecularly ; but under the conditions described in Part I, a bimolecular condensation product is obtained. However, in the present case, the condensation takes place under the conditions described in experimental sequel. But the catalytic reduction of (III, R=Me) to the substance (II, R_1=$CHMe_2$; R=Me) proved difficult. This scheme for the synthesis of oreoselone, which seemed so promising from the above model experiment, failed because ω-chlororesacetophenone does not react either with malic acid, hydroxymethylene acetic ester, ethoxymethylene acetic ester or acetoxymethylene acetic ester. But it has been found that ω-chlororesacetophenone condenses with oxaloacetic ester to give (I, R=CO_2Et) but with great difficulty. This result is reminiscent of the exceptional behaviour of oxaloacetic ester towards quinol with which other β-ketonic esters show little tendency to react.

The ring-closure of the substance (I, R=CO_2Et) to (II R_1=H ; R=CO_2Et) proves to be extremely difficult, all methods based on the use of sodium acetate in various solvents such as ethyl alcohol, dioxane, glycerin, phenol, pyridine, dimethylaniline fail. But ice-cold ammonia (d, 0·88) under carefully controlled condition brings about the desired transformation. The substance (II, R=CO_2Et ; R_1=H) condenses with acetone to give (III, R=CO_2Et). Hydrolysis, catalytic reduction and decarboxylation of (III, R=CO_2Et) will lead to oreoselone.

EXPERIMENTAL

4-Methyl -6-chloroaceto-7-hydroxycoumarin.—A mixture of ω-chlororesacetophenone (4 g.), ethyl acetoacetate (3 c.c.), absolute alcohol (35 c.c.) was saturated with dry hydrogen chloride in the ice-cold and left overnight in a flask tightly corked. Next morning, half the alcohol was removed by distillation and the residue poured over crushed ice. The pasty mass after treatment with ether became solid and crystallised from alcohol, m.p. 235-36°, yield 0.2 g. To a mixture of ω-chlororesacetophenone (4 g.), ethyl acetoacetate (4 g.), concentrated sulphuric acid (8 c.c.) was added in the ice-cold. The mixture was allowed to stand at 20-25° for 48 hours and then poured on to ice. The product isolated as before had m.p. 235·36°, yield 0.5g. (Found : C, 57.56 ; H, 3.55, $C_{12}H_9O_4Cl$ requires C, 57.3 ; H, 3.95 per cent).

Preparation of (II, R=Me ; R_1=H).—The foregoing substance (3.0 g.), dissolved in dioxane (60 c.c.) was mixed with powdered sodium acetate (15 g.) and heated on the steam-bath for 2 hours and finally gently refluxed for 15 minutes. After cooling, the mixture

was diluted with water and the precipitated solids crystallised from a mixture of benzene and petroleum ether, m.p. 267·68° (decomp.), yield 1 g. (Found : C, 66.78 ; H, 4.14. $C_{12}H_8O_4$ requires C, 66.66 ; H, 3.7 per cent). Attempts at *iso*propylation of the above compound in various solvents such as anisole, decalin, etc., with sodamide and *iso*propyl iodide failed. But it readily condensed with piperonal (piperidine condensing agent) to give a *piperonylidene* derivative, m. p. 290° (acetic acid). (Found : C, 69.12 ; H, 3.58. $C_{20}H_{12}O_6$ requires C, 68.96 ; H, 3.45 per cent.) showing the presence of $COCH_2$ grouping. The *coumaranone* (0.7 g.) dissolved in pure dimethylaniline (30 g.) was mixed with pure dry acetone (4 c.c.) and piperidine (3 drops). The mixture was heated at 120° for 2 hours and then at 150° for 2 hours. After the recovery of dimethylaniline by steam distillation, the residue was boiled with hydrochloric acid and filtered. The insoluble portion was crystallised from xylene-petroleum ether and had m.p. 232°. [Found : C, 70.44 ; H, 4.99. $C_{15}H_{12}O_4$ (III, R=Me) requires C, 70.31 ; H, 4.66 per cent].

β-Carboethoxy-6-chloroaceto-7-hydroxycoumarin (I, R=CO_2Et).—ω-Chlororesaceto-phenone did not condense with oxaloacetic ester in presence of sulphuric acid or phosphorous pentoxide. The condensation can be brought about as follows : ω-Chlororesacetophenone (4 g.), oxaloacetic ester (5 c.c.) and zinc chloride (well powdered, 4 g.) were well mixed and to this dry alcohol (40 c.c.) was added. The solution was then saturated with hydrogen chloride and the characteristic greenish fluorescence of an umbelliferone derivative appeared in 1 hour which ultimately became greenish black. After standing at the room temperature (20-25°) for 48 hours the separated product (A) was collected and the filtrate left for 4 days. After collecting the deposit (B), the filtrate was poured on to ice and the semi-solid mass extracted with ether. The residue (C) from ether was mixed with (A) and (B). The mixed solids were crystallised from carbon tetrachloride and also from benzene-ligroin, yield 3 g. (Found : C, 53.98 ; H, 4.01. $C_{14}H_{11}O_6Cl$ requires C, 54.1 ; H, 3.55 per cent).

The ring-closure of the substance (I, R=CO_2Et) to (II, R_1=H ; R=CO_2Et) proved to be extremely difficult. The chloro-ketone (1 g.) was ground with chilled (to 0°) liquor ammonia and the yellow solution left aside at the room temperature for 10-15 minutes when it turned dark red. It was then warmed on the steam-bath at 50-60° for 10 minutes. The solution was again well cooled and neutralised with hydrochloric acid below 5°. The greenish precipitate was well washed, collected, dried and finally crystallised from benzene-ligroin mixture, m.p. 179-81°, yield 0.6 g. The greenish colour of the crude product is due to a complex impurity which is eliminated during crystallisation. (Found : C, 61.4 ; H, 3.75. $C_{14}H_{10}O_6$ requires C, 61.3 ; H, 3.65 per cent). The substence was nitrogen free and non-acidic.

The coumaranone (II, R=CO_2Et ; R_1=H) (0.7 g.), dissolved in pure dimethylaniline (30 c.c.), was mixed with acetone (3 c.c.) and piperidine (3 drops) and heated at 120° (2-3 hours) and at 150° (2 hours). The product, isolated as previously, crystallised from dilute methanol and also from a mixture of acetone and carbon tetrachloride, m. p. 264-66° (decomp.). [Found : C, 65.22 ; H, 5.15. $C_{17}H_{14}O_6$ (III, R=CO_2Et) requires C, 65.0 ; H, 4.45 per cent].

PHENYLTHIOCARBAMIDES. A CONTRIBUTION TO THE STUDY OF THE TRIAD —N.C.S—. PART XVII. PHENYL-, p-CHLOROPHENYL- AND p-TOLYL CYANAMIDES

By B. Singh, H. Krall and R. Sahasrabudhey

p-Chlorophenyl- and p-tolylcyanamides have been prepared and their chemical properties studied. Nitrous acid reacts with the cyanamides affording nitroso derivatives' Both acid and alkalihydrolyse the compounds yielding ureas as primary products.

In an earlier paper (*J. Indian Chem. Soc.*, 1942, **19**, 343) Krall and Sahasrabudhey have already dealt with certain aspects of the chemistry of phenylcyanamide. The present communication records an extension of that work and investigations on p-chlorophenyl- and p-tolylcyanamides.

Like phenylcyanamide these derivatives can be prepared in comparable yields by the desulphurization of the corresponding thiocarbamides. The p-tolylcyanamide forms a monohydrate at about —5°, while all attempts at the hydration of the p-chloro compound have proved unsuccessful (Krall *et al., loc. cit.*).

The compounds undergo polymerization to the correspondingly substituted *iso*-melamines, but ethereal solutions, dehydrated over ignited sodium sulphate, can be stored for long periods without any appreciable change.

Unlike the cyanamide itself, which polymerizes under cretain well defined conditions only (Werner, *J. Chem. Soc.*, 1915, **107**, 715), the phenylcyanamide and its p-chloro- and p-methyl derivatives polymerize in more varied circumstances. It appears that a positive substituent in general renders polymerization easier. At ordinary temperatures, phenyl-cyanamide and p-chlorophenylcyanamide take about one week for complete polymerization, while under comparable conditions p-tolylcyanamide is completely polymerized in almost half this period. Attempts at the preparation of aminocyanamide resulted in the isolation of a derivative of its dipolymer (*J. Indian Chem. Soc.*, 1941, **18**, 225), formed evidently from the aminocyanamide which must have been the primary product but had a transitory existence only. As a first approximation therefore, the ease of polymerization of the various derivatives can be represented in the following order :

$$NH_2.NH.CN > NH_2.CN > Me.C_6H_4.NH.CN > Cl.C_6H_4.NH.CN$$
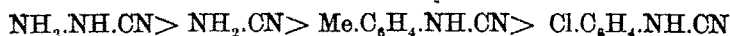
A systematic investigation of the kinetics of polymerization of the various substituted cyanamides is intended but the analytical difficulties are considerable.

Solubility of these compounds in alkali and acid indicates their amphoteric character. A sulphate and a sodium salt have been obtained from phenylcyanamide (*loc. cit.*) for which the following structures are suggested :

$$[Ph.\overset{\alpha}{N}H\overset{\oplus}{-}C\equiv \overset{\beta}{N}H]\ \overset{\ominus}{H}SO_4 \qquad\qquad Ph.N(Na)CN$$
$$\text{(I)} \qquad\qquad\qquad\qquad \text{(II)}$$
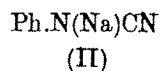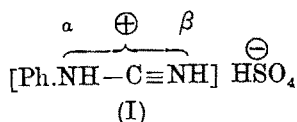
(I) on heating forms sulphanilic acid recalling the isomeric change of aniline sulphate. This suggests a structural analogy between the two compounds and points to the re-

activity of α-nitrogen atom in the former, as indeed is further borne out by (11) and the existence of a nitroso derivative Ph.N(NO)CN and their many reactions (*loc. cit.*). This can be explained as follows.

The phenyl and the cyano groups, both being strongly electron-attracting, induce a positive charge at the α-nitrogen atom by inductive effect, the latter to acquire the electrostatic equilibrium ejects out a proton. This behaviour recalls the similar reactivity of the hydrogen atom in benzylcyanide (Sidgwick, "Organic Chemistry of Nitrogen", Oxford University Press, p. 314) and can be represented by the following scheme.

$$Ph—\overset{\frown}{N}\overset{\frown}{H}—CN \qquad Ph—\overset{\frown}{N}\overset{\frown}{H}—CN \qquad \overset{\oplus}{H}+Ph—\overset{\frown}{N}\overset{\ominus}{—}\overset{\frown}{C}N$$

$$\text{(i)} \qquad\qquad \text{(ii)} \qquad\qquad \text{(iii)}$$
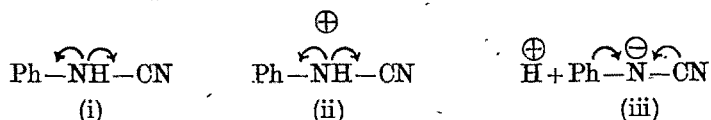
Confirmation of this has been obtained by the determination of the dissociation constant of *p*-chlorophenylcyanamide which is found to be about 2.05×10^{-7}; in the case of *p*-tolylcyanamide it is too small to be measured. Such behaviour is in accord with the above mechanism and also with the theory of strength of acids and bases (Watson, "Modern Theories of Organic Chemistry", Oxford University Press, 1937, pp. 33-40).

That the hydrogen of the imino group has an incipient tendency for ionization was suggested first by Sahasrabudhey in the case of phenylcyanamide. That such a tendency exists and can be augmented or suppressed by the —1 and +1 inductive effects of the adjoining groups has become apparent in these two cases.

Action of HNO₂.—Like phenylcyanamide *p*-chlorophenyl-, and *p*-tolylcyanamides react with nitrous acid in alcoholic medium to form the nitroso derivatives :

$$Cl\langle\quad\rangle N(NO) \text{ and } Me\langle\quad\rangle N(NO)CN$$
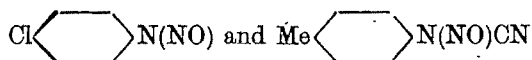
The formation of a nitroso derivative is usually considered as an evidence for the presence of a -NH-group. The formation of such compounds from above cyanamides and not from the corresponding thiocarbamides appears to us of considerable significance. The phenylthiocarbamide and its other aryl homologues, as also S-diarylthiocarbamides do not form nitroso derivatives. This suggests that the hydrogen of the imino group in the above cyanamides, though labile to a certain extent (*vide supra*), largely remains attached to the nitrogen ; in the case of thiocarbamides, however, a conventional -NH- appears to be wanting. It is known that a C=S-group exerts a far more powerful inductive effect than a C=O group (*J. Chem. Soc.*, 1929, 1584 ; 1925, 1618) and presumably a C≡N group. We suggest that a proton ejected from the imino group may find a place on the negatively charged sulphur causing tautomerism in these thioureas. Thus :

$$Ph—\overset{\frown}{N}\overset{\frown}{H}—\overset{\frown}{C}—NH_2 \quad Ph—\overset{\oplus}{N}H—\overset{\|}{C}—NH_2 \quad Ph—N=\overset{|}{C}—NH_2 \quad Ph—N=\overset{|}{C}—\overset{\oplus}{N}H_3$$
$$\overset{\|}{S} \qquad\qquad \overset{\|}{S} \qquad\qquad \overset{|}{S}H \qquad\qquad \overset{|}{S}$$

$$\text{(i)} \qquad \overset{\rightleftarrows}{} \qquad \text{(ii) } \ominus \qquad \overset{\rightleftarrows}{} \qquad \text{(iii)} \qquad \overset{\rightleftarrows}{} \qquad \text{(iv) } \ominus$$
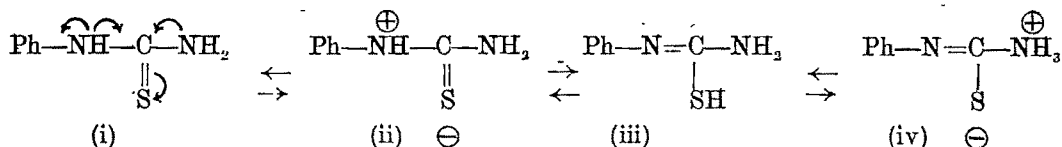
Hydrolysis.—Both acids and alkalis hydrolyse the *p*-chlorophenyl- and *p*-tolylcyanamides ; the primary products being the corresponding ureas. It will be evident from the table given in the experimental part that in an alkaline medium the *p*-tolylcyanamide is more easily hydrolysed, equilibrium being reached within 15 minutes at 75% change.

In the case of p-chloro compound more than an hour is required for reaching a stable equilibrium when nearly 60% have hydrolysed. Besides the ureas other products of hydrolysis are mainly ammonia and cyanic acid. Hydrolysis is more rapid in an alkaline medium probably because the cyanamides are weak acids. For the same reason acid hydrolysis is slow. The fact that p-chlorophenylcyanamide is more resistant than the p-tolylcyanamide supports the above view (*vide* experimental). These results recall the various studies on the hydrolytic decompositions (by Krall *et al*) of thiocarbamides where a positive substituent is known to weaken the $C \overset{a}{-} N$ bond.

<div align="center">EXPERIMENTAL</div>

Preparation of p-*Chlorophenyl- and* p-*Tolylcyanamides.*—1/30th Mole of the thiocarbamide (6.21 g. of chlorophenylthiocarbamide and 5.53 g. of tolylthiocarbamide) was suspended in 50 c.c. of boiling water and to this were added 50 c.c. of boiling aqueous solution containing 20.5 g. of KOH and 33 c.c. of boiling lead acetate solution containing 12.6 g. of lead acetate. The mixture was boiled for 5 minutes, cooled by surrounding with ice and filtered. Cyanamide was precipitated by the addition of a slight excess of glacial acetic acid, filtered and dried over concentrated sulphuric acid in a vacuum desiccator, yield of p-chlorophenylcyanamide 4.9 g. (98% of theory), m.p. 97° ; M.W. 152.5 ; yield of p-tolylcyanamide 4.0 g. (91% of theory), m.p. 63° ; M.W. 132.

Molecular weights were determined by cryoscopic methods and as would be apparent from the Table I no perceptible polymerization had occurred in the freshly prepared compound.

<div align="center">TABLE I</div>

Substance.	M.W. (found).	Method used.	Solvent.
p-Chlorophenylcyanamide	154, 149	Rast's	Camphor
	150	Beckman's	Nitrobenzene
p-Tolylcyanamide	131, 133	Rast's	Camphor
	130	Beckman's	Nitrobenzene

Hydration.—The compounds as isolated at the room temperature were found devoid of any water of hydration. When well dried samples were treated with water, cooled by a freezing mixture (—5°) a monohydrate was obtained in the case of p-tolylcyanamide. p-Chlorophenylcyanamide did not take up any water of crystallisation.

Polymerization.—These cyanamides left as such undergo polymerization to the corresponding *iso*melamines. In the case of p-tolylcyanamide, at ordinary temperatures about 2-3 days are required for complete polymerization, the chloro derivative polymerizing in about a week. At lower temperatures the polymerization proceeds more slowly, while if heated on a water-bath complete polymerization is effected within 45 minutes.

Tri-p-tolyl*iso*melamine, m.p. 256°. (Found : N, 21.4. Calc. N, 21.2 per cent).

Tri-p-chlorophenyl*iso*melamine, m.p. 280° (Found : N, 18.4, Calc., N, 18.3 per cent).

Action of Nitrous Acid. (In an alcoholic medium).—To 15 c.c. of a 10% solution of the cyanamide in alcohol were added 3 c.c. of concentrated hydrochloric acid. A saturated solution of sodium nitrite was then gradually added with constant stirring till effervescence ceased. Yellow nitroso derivatives separated out.

(*i*) The nitroso derivative of *p*-chlorophenylcyanamide was crystallised from alcohol, m.p. 183°. (Found : N, 23.6, 23.7 ; Cl, 19.7, 19.5. $C_7H_4ON_3Cl$ requires N, 23.9 ; Cl, 19.66 per cent).

(*ii*) The nitroso derivative of *p*-tolylcyanamide was crystallised from alcohol. (Found : N, 25.5. $C_8H_7ON_3$ requires N, 25.9 per cent).

Hydrolysis : Action of water, aqueous acid and alkali.—The solubility of the cyanamides under investigation is very low in water, of the order of 0.1 to 0.2%. If an aqueous solution is allowed to stand for several days *iso*melamines are precipitated. In boiling solutions other products also appear but were not examined. Traces of the corresponding ureas are formed (*p*-chlorophenylurea, m.p. 206° ; *p*-tolyl urea, m.p. 180°). The behaviour is comparable with phenylcyanamide. Both acids and alkalis hydrolyse these derivatives to the corresponding ureas ; *iso*melamines are not formed in any appreciable quantity. Other products of hydrolysis are ammonia, cyanic acid, CO_2 etc., formed probably as a result of the secondary decompositions.
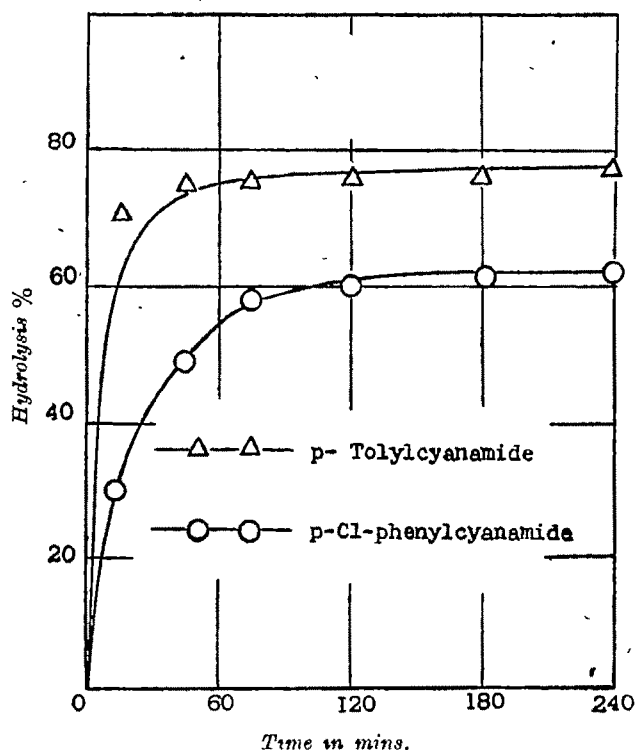
FIG. 1

Time in mins.

Alkali Hydrolysis.—1/200th Mole of the cyanamide taken in a 100 c.c. R.B. flask with an equivalent quantity of the hydrolysing agent (5 c.c. of normal NaOH solution) was boiled under a reflux condenser for the desired period. Unchanged cyanamide was then estimated titrimetrically (*vide J. Indian Chem. Soc.*, 1942, **19**, 343).

Acid Hydrolysis.—Preliminary experiments revealed that the acid hydrolysis is very slow as compared with alkali hydrolysis.

Time.	% Hydrolysis of *p*-chloro-phenylcyanamide.	% Hydrolysis of *p*-tolylcyanamide.
15 min.	30	71.0
45	49	75.1
60	55	75.2
75	58	75.2
120	60	75.6
180	60.5	76.0

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SYNTHETIC INVESTIGATIONS ON STEROLS, BILE ACIDS, HORMONES, ETC. PART III. STUDY OF THE DIECKMANN CONDENSATION PRODUCTS OF THE TRICARBOXYLIC ESTER OF 2-METHYLPENTANE-1 : 2 :5-TRICARBOXYLIC ACID

By Nirmalendu Kumar Chakravarty* and D. K. Banerjee

Cyclisation product of ethyl 2-methylpentane-1 : 2 : 5-tricarboxylate has been found to be a cyclopentanone derivative, as the product obtained by its hydrolysis has been identified with 2-methylcyclopentanone-2-acetic acid.

In a previous communication (Banerjee, *J. Indian Chem. Soc.*, 1940, **17**, 453) cyclisation of ethyl 2-methylpentane-1 : 2 : 5-tricarboxylate (I, R=Me) by means of sodium dust in benzene solution had been described. Obviously, hydrolysis of the cyclised product may lead to the formation of two different keto-acids, *viz.*, 2-methylcyclopentanone-2-acetic acid (II, R=R$_1$=H) and 3-methylcyclohexanone-3-carboxylic acid (III, R= CO$_2$H), depending upon the manner in which the ring-closure takes place. Actual hydrolysis of the β-ketonic ester was carried out by refluxing with 20% sulphuric acid and the keto-acid, thus obtained, on purification by distillation in vacuum solidified and melted at 68-69°. The semicarbazone of the above keto-acid melts at 202-203°.

In order to determine the constitution of the above keto-acid we have synthesised (II, R=R$_1$=H) by the following method.

2-Methylcyclopentanone is condensed with ethyl bromoacetate with the aid of sodamide in an ethereal solution (Dutta, *J. Indian Chem. Soc.*, 1940, **17**, 649). The higher boiling condensation product obtained therefrom is condensed with diethyl oxalate in an alcoholic solution of sodium ethoxide, and the resulting crude glyoxalic ester is pyrolised to yield ethyl 2-methyl-5-carbethoxycyclopentanone-2-acetate (II, R=C$_2$H$_5$, R$_1$= CO$_2$C$_2$H$_5$). The desired keto-acid (II, R=R$_1$=H) is obtained by the hydrolysis of the ketonic ester in the usual manner. When the fission of the crude glyoxalic ester is carried out by treatment with an aqueous solution of baryta, the yield of the keto-acid could be further improved. The melting points and the mixed melting points of the above keto-acid and its semicarbazone are found to be identical with those of the keto-acid and the corresponding semicarbazone obtained by the hydrolysis of the cyclised product of (I). The synthesis of the keto-acid (II, R=R$_1$=H) had previously been described by Robinson and King (*J. Chem. Soc.*, 1941, 465) by a similar method but they obtained the acid as a liquid without any purification and in poorer yield and they did not describe any derivative of the above keto-acid With a view to preparing the keto-acid (III, R=CO$_2$H), the other possible hydrolysis product of (I, R=Me), we have investigated the addition of hydrogen cyanide to 3-methyl-2-cyclohexenone and under the conditions described, have obtained a moderately good yield of 3-methyl-3-cyanocyclohexanone (III, R=CN).

It is interesting to note in this connection that Perkin and co-workers (*J. Chem. Soc.*, 1909, **95**, 2010) carried out the cyclisation of ethyl pentane-1:2:5-tricarboxylate (I, R=H)

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* Since deceased.

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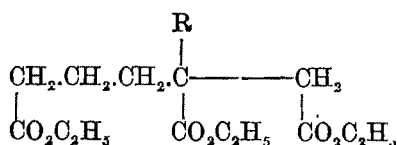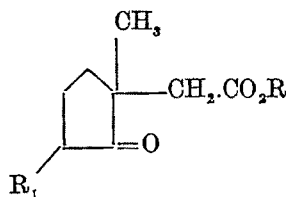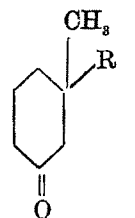
(I)   (II)   (III)

by means of sodium in benzene solution and obtained *cyclo*hexanone-3-carboxylic acid by hydrolysis of the cyclised product, the identity of which was proved by an independent synthesis. Later, however, Chatterjee, Das and Barpujari (*J. Indian Chem. Soc.*, 1940, **17**, 161) observed that ethyl 2-carbethoxy*cyclo*pentanone-2-acetate (IV) on boiling in an alcoholic solution with molecular quantity of sodium ethoxide was transformed into ethyl 5-carbethoxy*cyclo*pentanone-2-acetate (V), the probable mechanism of the reaction being the alcoholysis to ester (I, R=H) and subsequent ring-closure. The constitution of the ester (V) was established by its hydrolysis to *cyclo*pentanone-2-acetic acid. In view of the anomalous results mentioned above, we have repeated the experiments of both sets of workers and our results agree with those of previous workers in every respect.
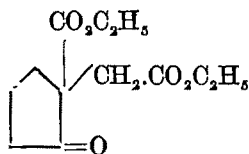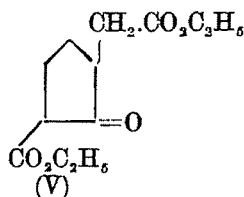
(IV)   (V)

EXPERIMENTAL

Hydrolysis of the cyclised product of Ethyl 2 - *Methylpentane*-1 : 2 : 5 *tricarboxylate.*—
The Dieckmann product (Banerjee, *loc. cit.*, 30 g.) was refluxed with sulphuric acid (20%, 350 c.c.) for 16 hours. The cooled solution was thoroughly extracted with ether after saturation with ammonium sulphate. The ethereal solution was dried over sodium sulphate and ether removed. The residue on distillation boiled at 160°/10 mm. and on standing solidified, m.p. 68-69°. (Found : C, 61.05 ; H, 7.5. $C_8H_{12}O_3$ requires C, 61.5 ; H, 7.7 per cent).

The *semicarbazone* was prepared by warming the keto-acid with a saturated aqueous solution of semicarbazide hydrochloride and sodium acetate. On crystallisation from water it melted at 202-203°. (Found : N, 19.1. $C_9H_{15}O_3N_3$ requires N, 19.7 per cent).

Condensation of 2-Methylcyclopentane with Ethyl Bromoacetate.—2-Methyl*cyclo*pentanone (13.8 g.) and finely divided sodamide (6.5 g.) in ether (200 c.c.) were heated under reflux in a three-necked flask fitted with a mercury-sealed mechanical stirrer for 4 hours. The volume of the ethereal solution was then reduced to 100 c.c. The flask was then cooled in ice and water and ethyl bromoacetate (30 g.) was slowly added with stirring. After half an hour the reaction mixture was again refluxed for 1 hour. After cooling water

was added and the ethereal layer separated, washed and dried.   After removal of ether a fraction (9 g.) boiling at 125-135°/12 mm. was collected.

2-*Methyl*cyclopentanone-2-*acetic   Acid*.—Diethyl oxalate (4.8 g.) was added to sodium ethoxide solution (from 0.8 g. Na and 10 c.c. absolute alcohol), cooled in a freezing mixture and shaken until a clear solution resulted.   5.7 G. of the above condensation product were then added to it and left overnight.   The reaction mixture was then treated with ice-cold distilled water and the neutral material was removed by extraction with water. The aqueous layer after acidification in the cold was thoroughly extracted with ether. After removal of ether the residue was heated at 180-190° with the addition of soft glass powder until the evolution of carbon monoxide ceased, when on distillation 3.5 g. of a product boiling at 162°/6 mm. were obtained.

Hydrolysis of the   β-ketonic ester was carried out by refluxing with 20% sulphuric acid (90 c.c.) and the keto-acid was isolated in the usual way.   The product on purification by distillation in vacuum solidified, m.p. 66-68°, mixed m.p. 68-69°.

The semicarbazone, prepared in the usual manner, on recrystallisation from water melted at 202-203°.

3-*Methyl*-3-*cyano*cyclo*hexanone*.—To a solution of 3-methyl-2-*cyclo*hexenone (11 g.) (Smith and Rouault, *J. Amer. Chem. Soc.*, 1943, **65**, 633) and glacial acetic acid (6 c.c.) in rectified spirit (102 c.c.) cooled in a freezing mixture, was added a solution of potassium cyanide (13 g.) in water (38 c.c.) over a period of half an hour with stirring.   The flask was kept at 0° overnight.   The reaction mixture was diluted with water and thoroughly extracted with ether after saturation with sodium chloride.   Ether was removed and the residue distilled in vacuum. The keto-nitrile (10 g.) was obtained, b.p. 152°/19mm. (Found : C, 69.8 ; H, 7.9. $C_8H_{11}ON$ requires C, 70.07 ; H, 8.03 per cent).

The semicarbazone was prepared in the usual manner and after crystallisation from dilute alcohol it melted at 182°.   (Found : C, 55.8 ; H, 7.52. $C_9H_{14}ON_4$ requires C, 55.99 ; H, 7.21 per cent).

Our thanks are due to Prof. P. C. Mitter for the interest he has taken during the progress of this work and also to Mr. N. N. Ghosh for microanalysis.

THE REACTIVITY OF 2-CHLORO-3 : 5-DINITRODIPHENYL

By S. H. Zaheer and I. K. Kacker

2-Chloro-3 : 5-dinitrodiphenyl has been successfully condensed with sodioacetoacetic ester by directly heating the mixture of the two without any solvent giving 81% yield of the condensation product, thus disproving its reported non-reactivity by Bradsher and Amore. 2-Bromo- and 2-iodo-3 : 5-dinitrodiphenyl have also been prepared.

Bradsher and Amore (*J. Amer. Chem. Soc.*, 1944, **66**, 1283) reported their failure to condense 2-chloro-3 : 5-dinitrodiphenyl either with sodio-malonic or acetoacetic esters, the condensation being attempted by them in benzene, dioxane, benzene-xylene (1 : 1) and absolute methyl and ethyl alcohols. While the original compounds were recovered unchanged when dioxane, benzene or benzene-xylene (1 : 1) were used as a solvent, the corresponding alkoxy derivatives were formed when methyl or ethyl alcohols were used. This behaviour of 2-chloro-3 : 5-dinitrodiphenyl is unexpected because the chlorine atom in 2 : 4-dinitrochlorobenzene is known to be very reactive (Richter, *Ber.*, 1888, **21**, 2470 ; Reissert and Heller, *ibid.*, 1904, **37**, 4364 ; Borsche, *ibid.*, 1909, **42**, 601). The alleged inactivity of the chlorine atom in the corresponding diphenyl derivative was attributed by Bradsher (*loc. cit.*) to the steric influence of the large phenyl group in the *ortho* position to the chlorine atom, which prevented the bulky ester anion to approach the halogen atom but offered little hindrance to the relatively small alkoxide ion.

The above explanation does not appear plausible to the present authors as the chlorine atom in this diphenyl compound is known to react with aniline, phenylhydrazine (Borsche and Scholten, *Ber.*, 1917, **50**, 596) and piperidine (Bradsher and Amore, *loc. cit.*).

This was therefore repeated using absolute ether as a solvent. It is found that condensation between 2-chloro-3 : 5-dinitrodiphenyl and sodio-acetoacetic ester occurs, sodium chloride being separated, but the yield of the condensation product isolated is very poor (2-3% of theory). The separation of sodium halide reaches a maximum after refluxing for more than six to seven hours and does not increase appreciably even on very prolonged refluxing (up to 58 hours). It has been found that the use of twice the molecular proportion of sodio-acetoacetic ester (*cf.* Borsche, *Ber.*, 1909, **42**, 601) has a marked effect on the efficiency of the reaction and the isolation of the product offers less difficulty. The products in such condensations have been observed to take time in crystallisation.

In the hope of getting better yields 2-bromo- and 2-iodo-3 : 5-dinitrodiphenyl have been prepared and used in place of the corresponding chloro compound but the yield does not improve.

It was thought unnecessary to use any solvent at all in a condensation of this type, particularly when a substance melts at a temperature reasonably below the temperature at which the sodium derivative of acetoacetic ester is likely to decompose. This modification enables the reaction to be carried out at a much higher temperature than the boiling point of ether and also avoids the diluting effect of the solvent, if any.

This modification in the method gives very good results and 3 : 5-dinitrodiphenyl-2-acetoacetic ester is obtained in 81% yield. The direct condensation, without any solvent, of a reactive halide with the sodium derivative of acetoacetic ester does not appear to have been previously reported and the present authors are of the opinion that it can be advantageously employed in a variety of similar condensations.

<div align="center">EXPERIMENTAL</div>

2-Chloro-3 : 5-dinitrodiphenyl was prepared by the present authors from 3 : 5-dinitrodiphenyl-2-amine sulphate by the method of Bradsher and Amore (*loc. cit.*). In the preparation of 2-*p*-toluene sulphonamidodiphenyl required as an intermediate compound for preparing the corresponding halides, the authors esentially used the method described by Bell (*J. Chem. Soc.*, 1928, 2270). Either pyridine (*cf.* Case, *J. Amer. Chem. Soc.*, 1945, **67**, 119) or sodium carbonate can be used as a condensing agent in the preparation of this *p*-toluene sulphonamide, giving almost theoretical yields. It was also found necessary to use only half the amount of glacial acetic acid used by Bell (*loc. cit.*) for dissolving the 2-*p*-toluene sulphonamidodiphenyl prior to its nitration to 3 : 5-dinitro-2-(*p*-toluene sulphonamido)-diphenyl by fuming nitric acid and acetic acid (1 : 1).

2-*Bromo*-3 : 5-*dinitrodiphenyl.*—3 : 5-Dinitrodiphenyl-2-amine sulphate (5g.), prepared as described by Bradsher (*loc. cit.*), was diazotised by dissolving it in 8 c.c. of nitrosylsulphuric acid at room temperature with mechanical stirring for 2 hours. The resulting solution of the diazonium compound was slowly added to an ice-cooled solution of cuprous bromide (in 5 c.c. hydrobromic acid of sp. gr. 1.49) obtained from 2.5 g. of copper sulphate. The stirring was continued for 1 hour more and the yellow solid filtered at the pump and subsequently decomposed by warming with water on a water-bath till no more nitrogen was evolved. The solid was then filtered, washed with a very dilute solution of caustic soda and crystallised from alcohol to give shining yellow crystals, m.p. 110-11°, yield 3.5 g. (Found : N, 8.68. $C_{12}H_7O_4N_2$ Br requires N, 8.66 per cent).

2-*Iodo*-3 : 5-*dinitrodiphenyl.*—3 : 5-Dinitrodiphenyl-2-amine sulphate (10 g.) was diazotised by dissolving it in 16 c.c. of nitrosylsulphuric acid as in the previous case. This was then treated with 10 g. of potassium iodide in 10 c.c. of water. The solid iodo compound was isolated as usual and crystallised from hot alcohol to give brownish yellow plates, m.p. 132-33°, yield 9 g. (Found : N, 7.67. $C_{12}H_7O_4N_2I$ requires N, 7.57 per cent).

3 : 5-*Dinitrodiphenyl-2-acetoacetic Ester.* (*a*) *Without the use of a solvent.*—Sodium (0.9 g., 0.04 mole) was reacted with ethyl acetoacetate (5.2 g., 0.04 mole) using anhydrous ether in a three-necked flask (250 c.c.) fitted with a dropping funnel, a reflux condenser and a mercury-sealed mechanical stirrer. The condenser was then quickly replaced by a calcium chloride tube and the ether was evaporated off, the dropping funnel removed and 2-chloro-3 : 5-dinitrodiphenyl (5.5 g., 0.02 mole) was quickly added and the mouth closed by a stopper. The contents were then heated for 4 hours with continuous stirring in an oil-bath at 100-10°. After 4 hours, the flask was cooled in ice, 100 c.c. of ether were added and the flask left overnight in the refrigerator. Next morning,

the red ethereal portion was decanted into a separating funnel and extracted four times with 50 c.c. lots of ice-cold 3% caustic soda. The paste left in the reaction flask was stirred with a cold 3% caustic soda solution till it completely dissolved. All the alkali extracts were combined and acidified with cold dilute nitric acid. A semi-solid brown mass separated. It was redissolved in cold caustic soda (3%) and the solution acidified with cold dilute nitric acid when a yellow fluffy mass was obtained, which on standing for 4 hours could be filtered. On crystallisation from a small quantity of alcohol it gave yellow crystals, m.p. 102-3°, yield 6 g. (Found : N, 7.53. $C_{18}H_{16}O_7N_2$ requires N, 7.53 per cent).

(b) *In anhydrous ether.*—A solution of 2-chloro-3 : 5-dinitrodiphenyl (2.7 g., 0.01 mole) in dry ether (80 c.c.) was added during the course of about 1 hour to the sodium derivative of acetoacetic ester in ether obtained from acetoacetic ester (2.6 g., 0.02 mole) and sodium (0.04 g., 0.02 mole). The mixture was refluxed for 24 hours. A clear red solution was obtained after refluxing for 2-3 hours. The contents were treated as described above, the final product being a yellow crystalline solid, m.p. 103° (mixed m.p. with the above condensation product), yield 2-3% of theory.

The condensation with the corresponding bromo and iodo compounds was carried out similarly in ether giving the same poor yields. Refluxing up to 58 hours did not increase the yield. The major portion of the halides could be recovered unchanged.

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ACTION OF *p*-TOLUENE SULPHONYL CHLORIDE ON NITROPHENOLS

By A. B. SEN

The action of *p*-toluene sulphonyl chloride on a number of substituted nitronaphthols, nitrocresols, dinitrodihydroxydiphenyl and 1 : 2-dihydroxyanthraquinone has been studied. Condensation either in the presence of diethylaniline or sodium carbonate results in the formation of a *p*-toluene sulphonyl ester, in every case. 1 : 2-Dihydroxyanthraquinone although containing two hydroxy groups yields only a monotolyl sulphonyl derivative ; the inactivity of one of the hydroxyl groups (occupying position 1) has been attributed to the presence of two *ortho* substituents. The reactivity of these esters with aniline has also been studied.

Nitrophenols react with *p*-toluene sulphonyl chloride in two ways : (1) Mononitrophenols yield *p*-toluene sulphonyl esters in the presence of sodium carbonate or diethylaniline as the condensing agent ; (2) poly-nitrophenols, having nitro groups in 2 : 4 or 2 : 6 positions also yield such esters in the presence of sodium carbonate as the condensing agent but are converted mainly into poly-nitrochlorobenzenes in the presence of diethylaniline (Ullmann and Nadai, *Ber.*, 1908, **41**, 1870 ; Ullmann and Bruck, *Ber.*, 1908, **41**, 3939 ; Ullmann and Sane, *Ber.*, 1911, **44**, 3730 ; Sane and Joshi, *J. Chem. Soc.*, 1924, 2481 ; *J. Indian Chem. Soc.*, 1932, **9**, 59 ; 1933, **10**, 313, 459 ; Sane, Chakravarty and Pramanick, *ibid.*, 1932, **9**, 55).

In the present paper this reaction has been extended to 1 : 6-dinitro-β -naphthol, 4-nitro-α -naphthol, 1-nitro-6-bromo-β -naphthol, 1 : 3 : 6-tribromo-β -naphthol, 5 : 5′-dinitro-2 : 2′-dihydroxydiphenylmethane, 2-nitroresorcinol, 2-nitro-*p*-cresol, 2-nitro-6-bromo-*p*-cresol and 1 : 2-dihydroxyanthraquinone, with a view to studying the replacibility of the hydroxyl groups, specially in the presence of NO$_2$ and Br groups, when they are present in positions other than 2 : 4 or 2 : 6 or in different nuclei. In every case a *p*-toluene sulphonyl ester is obtained, either in the presence of sodium carbonate or diethylaniline, showing thereby that these groups have little or no effect when they are present in positions other than 2 : 4 or 2 : 6. However, a marked difference in the reactivity of these compounds towards aniline is brought about by the presence of these groups. It is observed that only those tosyl derivatives of naphthol, which contained a NO$_2$ group in the *ortho* position to the OH and another NO$_2$ or Br (acid) group in the second benzene ring, react easily with aniline ; others without such a grouping fail to give this reaction—thus the tosyl derivatives of 4-nitro-α -naphthol and 1 : 3 : 6-tribromo--β-naphthol could not be made to condense with aniline. It may be recalled that the behaviour of these compounds in this respect is similar to the behaviour of the tosyl derivatives of azonitrophenols observed by the author previously (*Proc. Nat. Acad. Sci. India*, 1937, **7**, 218) ; 1 : 2-dihydroxyanthraquinone although containing-two OH gruops yields only a monotosyl derivative. This compound has been assigned the constitution 1-oxy 2-tosyl-anthraquinone, as it is believed that the OH group in position 1 is unable to react due to steric hindrance.

TABLE I

Nitrophenol used.	Wt. of Nitrophenol.	Wt. of p-toluene sulphonyl chloride.	Yield of tosyl ester using		M p.	Formulae of Tosyl ester.	Analysis		Reactivity with aniline.	M.p.	N in the anilide.	
			Diethyl aniline.	Sodium carbonate.			S (found).	S (calc.)			Found.	Calc.
(1) 1:6-Dinitro-β-naphthol	2.3 g.	2.0 g.	3.0 g.	3.2 g.	181°	$C_{17}H_{12}O_7N_2S$	8.1%	8.2%	Reactive	195°	13.3%	13.6%
(2) 4-Nitro-α-naphthol	2.2	2.0 g.	2.9	3.3	138°	$C_{17}H_{13}O_5NS$	9.5	9.3	Not reactive	—	—	—
(3) 1-Nitro- 6-bromo-β naphthol	2.7	2.0 g.	4.2	3.8	145°	$C_{17}H_{12}O_5NBrS$	7.3	7.6	Reactive	156°	8.1	8.1
(4) 1:3:6-Tri-bromo-β naphthol	3.8	2.0 g.	2.6	2.8	150°	$C_{17}H_{11}O_3Br\ S$	5.94	6.0	Not reactive	—	—	—
(5) 5:5'-Dinitro-2:2-dihydroxy-diphenyl-methane	1.5	2.0 g.	2.7	2.6	155°	$C_{27}H_{22}O_{10}N_2S_2$	10.54	10.7	—	—	—	—
(6) 2-Nitroresorcinol	1.6	2.0 g.	3.7	3.5	140°	$C_{20}H_{17}O_8NS_2$	13.68	13.8	—	—	—	—
(7) 2-Nitro-4-methylphenol	3.0	4.0 g.	5.4	5.2	91°	$C_{14}H_{13}NO_5S$	10.6	10.4	—	—	—	—
(8) 2-Nitro-4-methyl- 6-bromophenol	2.3	2.0 g.	2.1	2.4	128°	$C_{14}H_{12}O_5NBrS$	8.03	8.3	—	—	—	—
(9) 1 : 2-Dihydroxyanthraquinone	2.4	4.0 g.	3.4	3.2	211°	$C_{21}H_{14}O_6S$	7.9	8.1	—	—	—	—

<center>EXPERIMENTAL</center>

The toluene sulphonyl (tosyl) esters of the nitrophenols were obtained by condensing the appropriate nitrophenol with *p*-toluene sulphonyl chloride either in the presence of sodium carbonate or diethylaniline. The exact method followed in the case of 1 : 6-dinitro-β naphthol is given below.

1 : 6-*Dinitronaphthalene-2-toluene sulphonyl ester* : (a) *Condensation in the presence of sodium carbonate.*—1 : 6-Dinitro-β-naphthol (2.3 g.) and *p*-toluene sulphonyl chloride (2 g.) were suspended in 20 c.c. of boiling water, contained in a flask. Solid sodium carbonate was then added to it little by little. Each addition produced a coloration which disappeared on heating. The addition of sodium carbonate was stopped when further addition failed to produce such coloration. The contents of the flask were then cooled, the solid matter which separated out was washed thoroughly with water and then filtered, dried and recrystallised from glacial acetic acid, m.p. 181°, yield 3. g.

(b) *Condensation in the presence of diethylaniline.*—1 : 6-Dinitro-β-naphthol (2.3 g.), *p*-toluene sulphonyl chloride (2 g.) and diethylaniline (10 c.c.) were heated on the water-bath for 4 hours. After cooling, the diethylaniline was decomposed with dilute hydrochloric acid when a solid mass separated out. This was washed with hot water several times, filtered and finally recrystallised from glacial acetic acid, m.p. 181°, yield 3.2 g. (Found : S, 8.1. $C_{17}H_{12}O_7N_2S$ requires S, 8.2 per cent).

The other nitrophenols were condensed with *p*-toluene sulphonyl chloride by following the same method. The results obtained are given in Table I.

1 : 6-*Dinitronaphthalene-2-phenylamine.*—The *p*-toluene sulphonyl ester of 1 : 6-dinitronaphthol (1 g.) was refluxed with 5 c.c. of freshly distilled aniline for about 15 minutes. The excess of aniline was removed with hydrochloric acid, after cooling the contents of the flask. A yellow solid compound separated out. This was repeatedly washed with hot water, filtered, dried and finally recrystallised from glacial acetic acid, m.p. 195°, yield 0.7 g. (Found : N, 13.3. $C_{16}H_{11}O_4N_3$ requires N, 13.6 per cent).

1-*Nitro-6-bromonaphthalene-2-phenylamine* was obtained as before by refluxing the tosyl derivative of 1-nitro-6-bromo-β-naphthol (1 g.) with 5 c.c. of freshly distilled aniline, m.p. 156°, yield 0.6 g. (Found : N, 8.1. $C_{16}H_{11}O_2N_2Br$ requires N, 8.1 per cent).

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BROKEN BONDS AS SEATS OF ION EXCHANGE IN CRYSTALLINE SILICATES

By R. P. Mitra

Many crystalline silicates take up cations from solutions in contact with the solid phase in exchange for cations already present in the solid. These exchangeable cations are essential constituents of the silicate lattice being held opposite potentially negative positions of the lattice and still accessible to the cations of the ' contact solution.' The cation exchange capacity of a given weight of the mineral often markedly increases on grinding it to extreme fineness, as by this process a large number of cations, originally located in the interior of the lattice, is exposed and made accessible to the cations of the contact solution. Of particular interest is the cation binding capacity of silicates having sheetlike structures, e.g., kaolinite, in which the sheets themselves are neutral being made up of Si-O tetrahedra and Al-O (or, OH) octahedra. There are no metal cations in the lattice (required for balancing negative charges arising from isomorphous replacements) which can be exchanged for those of an added electrolyte, and yet finely ground kaolinite has been found to take up cations from solutions to the extent of 100.5 milliequivalents per 100 g. of the solid (Kelley and Jenny, *Soil Sci.*, 1936, **41**, 367). To what is this cation binding power due ? One answer to this question which has been frequently given will be examined here. It has been suggested that the cations are held on the lateral surfaces of the sheets where unsatisfied valencies are developed as a result of lattice termination (Hendricks, *Ind. Eng. Chem.*, 1945, **37**, 625). The lateral surface increases on grinding which produces fracture parallel to the c-axis by breaking valence bonds between Si and O, and between Al and O (or, OH). The fact that the cation binding capacity of kaolinite increases on grinding (Kelley *et al.*, *loc. cit.*) is, on this theory, to be attributed to an increase in the number of the broken bonds.

An important aspect of these broken bonds appears to have been either overlooked, or, misunderstood. To appreciate this we shall first consider what happens when the bond between two linked tetrahedra or octahedra breaks, *i.e.*, when an Si-O-Si bond, or, an Al-O (or, OH)-Al bond is ruptured Evidently, the oxygen ion can go with only one of the silicons (or aluminiums) linked by it, and the OH ion, with only one of the aluminiums. The Si or Al, which takes the O or OH, becomes negatively charged and a positive charge is left with the other Si or Al. Taking next the case of a linear silicate polymer, *i.e.*, a pyroxene, the " principle of microscopic neutrality " requires that potentially positive and negative ends or poles be produced simultaneously and in equal numbers by the rupture of the Si-O-Si bonds. Comminution of any ionic crystal would proceed on the same principle and fractures of kaolinite crystals parallel to the c-axis would be no exception. The finely ground solid would therefore *tend* to take up equal number of cations and anions from a contact solution and not merely cations as Kelley and Jenny (*loc. cit.*) argue in criticising Hofmann's suggestion (*Z. angew. Chem.*, 1934, **47**, 539) that the exchangeable cations in layer-lattice silicates are held by broken bonds on the edges of the Si-O planes. Their criticism would be certainly valid if only a cation binding power were attributed to the broken bonds. Actually, however, the bonds would tend to bind

both cations and anions.   In other words, *the bonds, as they break, give a potentially ampho-teric character to the comminuted solid.*

Whether the broken bonds in a given ionic crystal will at all remove cations and anions from a contact solution to the solid phase is a question is left open for the present. In a search for the relevant factors one would perhaps have to bring in considerations of the actual strengths and separations of the positive and negative poles, the extent to which the bonds are ionic, the structural peculiarities of the surface and specific properties, *e.g.*, valency, polarisability, size and state of hydration of the cations and anions of the contact solution.   The broken bonds may even be satisfied by adsorbing oriented water dipoles. Fuller discussion of these aspects is deferred pending completion of investigations on them, now in progress. What is intended to be emphasised here is that if a cation binding power is at all attributed to the broken bonds, as has been done by Hendricks (*loc. cit.*), Hofmann *et al* (*loc. cit.*), Grim (*J. Geol.*, 1942, **51**, 225) and others in the case of certain layer-lattice aluminosilicates, an anion binding capacity of these minerals due to the same cause has also to be recognised, *i.e.*, the minerals must be considered amphoteric and not merely acidic.   This aspect of broken Si-O-Si and Al-O (or, OH)-Al bonds deserves careful consideration in view of Mattson's experiments (*Soil Sci.*, 1931, **32**, 143) which show that soil colloids now known to consist principally of certain well known aluminosilicates of the layer-lattice type do possess an amphoteric character. Hydrargillite containing Al-OH-Al bonds is definitely amphoteric. The available evidence is unfortunately inconclusive on the question of broken Si-O-Si bonds of quartz as sites for ionic exchange.   Kelley and Jenny failed to detect any appreciable cation binding power of the ground mineral.   Jackson and Truog (*Proc. Soil Sci. Soc. Amer.*, 1939, **4**, 136), on the other hand, report a cation binding capacity to the extent of 60.0 m.e. per 100 g.   No data on the anion binding power of ground quartz are available.   Apparently, further work on pure specimens of this and other minerals is necessary.

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ON THE PREPARATION OF ETHYL β-ETHOXYPROPIONATE

By M. Swaminathan

The preparation of ethyl β-ethoxypropionate in quantity is of great commercial importance as it is one of the starting materials for the manufacture of vitamin-B_1 according to the method of Williams and his colleagues (Cline, Williams and Finkelstein, *J. Amer. Chem. Soc.*, 1937, 59, 1052). A survey of the literature revealed that only a few reports have appeared in the past on the preparation of β-ethoxypropionic acid or its ester (Purdie and Marshall, *J. Chem. Soc.*, 1891, 59, 475 ; Jones and Powers, *J. Amer. Chem. Soc.*, 1924, 46, 2529 ; Cramer, Hunter and Hibbert, *J. Amer. Chem. Soc.*, 1939, 61,513 ; B.P. 496738). As the starting materials required for the above methods were not available in this country at the time this work was done, an altrenative method for the preparation of ethyl β-ethoxypropionate was explored. The possibility of preparing the compound by the action of sodium ethoxide on ethyl β-bromopropionate was tried as ethyl β-bromopropionate can be easily prepared starting from ethylene chlorohydrin according to the methods given in " Organic Synthesis " (Kendall and McKenzie, Vol. III, pp. 25, 51, 57). The present note describes the conditions which give high yields of ethyl β-ethoxypropionate (80-85% of the theory) on the basis of ethyl β-bromopropionate used.

Ethyl β-Ethoxypropionate.—Sodium (23 g., 1 gram atom) cut into pieces was added in small quantities at a time through one of the side necks of a 3-necked 1000 c.c. flask fitted with a reflux condenser and a dropping funnel containing 400 c.c. of absolute alcohol. When the sodium had completely dissolved, the mixture was cooled in ice-water. Ethyl β-bromopropionate (90.5 g., ½ mol.) dissolved in absolute alcohol (100 c.c.) was added in 10 c.c. portions with constant shaking. The addition of the bromo-ester was completed in 15 minutes. The mixture was allowed to stand overnight in cold water at room temperature and then heated for 2 hours on a steam-bath. Part of the ester was hydrolysed during this process. Sodium hydroxide (100 c.c., 20%) was then added and the mixture heated for one hour on the water-bath to hydrolyse completely all the ester. The mixture was cooled, just neutralised by the addition of concentrated hydrochloric acid and then made slightly alkaline to litmus by the addition of a few drops of sodium hydroxide (20%). The alcohol and water were distilled off on the water-bath under diminished pressure. The residue was taken up in 50 c.c. of water, acidified by the addition of sufficient concentrated hydrochloric acid (about 55 to 60 c.c. may be required till the mixture was acid to thymol blue) and saturated with sodium chloride when a greater portion of β-ethoxypropionic acid separated as an oil. The acid was separated and the aqueous layer extracted thrice with ether (100 c.c. each time). The ether extracts were mixed with the main bulk of the β-ethoxypropionic acid, dried over sodium sulphate and the solvent removed by distillation. The residue was dissolved in absolute alcohol (150 c.c.) and converted into the ester, following exactly the procedure described for the preparation of ethyl ethoxyacetate (' Organic Synthesis ', Vol. XIII, p. 42). The yield of the ester boiling at 166° at 755 m.m. was 65 g. (88% of the theory based on

ethyl β-bromopropionate used). The ester is quite pure and can be used straight-away for further synthetic operations.

In many typical experiments the yield ranged from 75 to 85% of the theory. The quantity of sodium ethoxide used affects the yields considerably. Good yields are obtained only by using 2 to 2.5 g. atoms of sodium for one molecule of ethyl β-bromopropionate. When only one gram atom of sodium (which is just the theoretical amount necessary) was used, the yields were very low, 20 to 25% presumably due to the formation of ethyl acrylate as a by-product. Excess of sodium ethoxide present presumably reacts with ethyl acrylate formed converting it into ethyl β-ethoxypropionate as observed by Purdie and Marshall (*loc. cit.*).

The author's thanks are due to Prof. G. Sankaran for his interest in this work.

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A NOTE ON THE IODOMETRIC ESTIMATION OF TRIVALENT ANTIMONY

BY SRIPATI PANI

The method of Dunstan and Boole (*Pharm. J.*, 1889, **19**, 385) for the iodometric estimtaion of trivalent antimony, in which sodium bicarbonate is used to neutralise the acid formed in the course of the reaction, suffers from the serious defect that if the titration is not finished quickly, antimonious oxide comes down as a precipitate. This is due to the neutralisation of the tartaric acid by sodium bicarbonate. It was thought that if sodium acetate was used, no neutralisation of the tartaric acid would take place and the titration could be carried smoothly ; but it was found that a very slight precipitation of antimonious oxide did take place. So small amounts of acetic acid were added to the solution containing tartar emetic and sodium acetate and no precipitation took place even if traces of acetic acid were present. As expected it was found that the reverse reaction, the reduction of antimonic acid by hydriodic acid, took place if the concentration of hydrogen ion was large, but up to a concentration of $N/32$ (in the solution to be titrated) there was no sign of the above reverse reaction having taken place.

The following is the summary of experimental results. 25 C.c. of $N/10$ tartar emetic were taken and 5 g. of sodium acetate were added in every case. The strength of the acetic acid which differed from solution to solution is indicated by [HAc] and the volume of iodine used is indicated by "V" in case of all the experiments.

[HAc]	N	$N/2$	$N/4$	$N/8$	$N/10$	$N/32$	$N/64$	O
"V"	18.1	18.15	18.2	18.2	18.2	18.25	18.25	18.25

At room temperature sodium bicarbonate method and sodium acetate-acetic acid method yield the same results. Only the titration is easier in the second case and one has not to hurry up.

I am thankful to Prof. B. Prasad for suggesting the problem to me.

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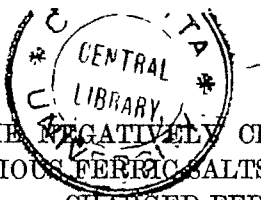
STUDIES IN THE NEGATIVELY CHARGED COLLOIDAL SOLUTIONS OF VARIOUS FERRIC SALTS. PART II. NEGATIVELY CHARGED FERRIC BORATE SOL

By Sukhdeo Prasad Mushran and Satya Prakash

The conditions of preparation of negatively charged ferric borate sol have been studied. The method principally consists in adding sodium borate solution to ferric chloride solution and dispersing the precipitate of ferric borate by caustic soda in presence of glucose or glycerine. The composition of the sol peptised in presence of glucose appears to be $11Fe_2O_3.2FeBO_3.3H_2O$, and of that peptised in presence of glycerine is probably $5Fe_2O_3.FeBO_3.24H_2O$.

Prakash and Dhar (*J. Indian Chem. Soc.*, 1929, **6**, 391) reported that when a saturated solution of borax was added gradually to ferric chloride solution, a bulky precipitate appeared which dissolved on shaking. After dialysis, a clear red sol was obtained which set to form transparent jellies on addition of KCl or K_2SO_4. Prakash and Dhar (*ibid.*, p. 587) also reported the formation of stannic borate jellies obtained by coagulating stannic borate sols. Mitra (*Proc. Nat. Acad. Sci. India*, 1939, **9**, 138) studied the periodic precipitation of ferric borate sol by the process of coagulation with electrolytes. The sols and gels investigated so far are charged positively. No work appears to have been done on the negatively charged ferric borate sols.

In a previous publication (*J. Indian Chem. Soc.*, 1946, **23**, 111), we have made attempts to study the negatively charged sols of ferric vanadate and in this paper our results on the negatively charged ferric borate sols are reported.

When borax is added to ferric chloride solution, a voluminous yellow precipitate of ferric borate is obtained. We have observed that this precipitate of ferric borate can be dispersed by caustic soda in presence of glucose or glycerine to give a bright red sol of ferric borate which bears a negative charge. Mushran and Prakash (*Allahabad Univ. Studies*, 1943, **19**, 1) have studied the detailed conditions of the preparation of this sol. The idea of peptisation can be had from the following figures.

1.0 to 2.0 c.c. of a ferric chloride solution (30.36 g. of Fe_2O_3 per litre) when mixed with 1.0 to 1.6 c.c. of 8% borax solution in presence of 0.6 to 1.0 c.c. of 20% glucose solution requires 3.0 to 4.6 c.c. of $N/3$-NaOH solution (total volume 10 c.c.) to bring about complete peptisation in half an hour.

1.0 to 2.0 c.c. of the same ferric chloride solution when mixed with 1.0 to 2.0 c.c. of 8% borax solution in presence of 0.5 to 3.0 c.c. of glycerine requires 3.0 to 4.8 c.c. of $N/3$-NaOH (total volume 10 c.c.) to bring about the complete peptisation in half an hour.

EXPERIMENTAL

Sol A was prepared by mixing 60 c.c. of a ferric chloride solution (30.36 g. of Fe_2O_3 per litre), 180 c.c. of 8% borax solution, 174 c.c. of 20% glucose solution and 200 c.c. of N-NaOH solution. The sol was purified by dialysis for a period of 10 days and was found quite stable.

Sol B was prepared by mixing 50 c.c. of the same ferric chloride solution, 240 c.c. of 8% borax solution, 120 c.c. of glycerine and 160 c.c. of N-NaOH solution. The sol was subjected to cold dialysis for purification. It was observed that the sol could not stand much dialysis. It was thrown out as a gelatinous mass during dialysis for a day. The sol under investigation was therefore dialysed for about twelve hours and was then

transferred to a Jena bottle. The dialysed sol was unstable and was thrown out in the course of seven days.

The amount of iron in a known volume of the sol was estimated by the use of the reagent cupferron. An analysis is presented in Table I.

TABLE I

Per litre.	Sol A Glucose sol.	Sol B Glycerine sol.
Total iron	1.2952 g.	1.3864 g.
Total borate (H_3BO_3)	0.6200	0.9610
Combined borate (H_3BO_3)	0.1240	0.1421
Free borate (H_3BO_3)	0.4960	0.8189
Combined iron	0.1120	0.1284
Free iron	1.1832	1.2580
Viscosity of sol (30°)	0 00835	0.00892*
Viscosity of water (30°)	0.00803	0.00803
Water, bound	0.05626	0.99310
Empirical formula	$11Fe_2O_3.2FeBO_3.3H_2O$	$5Fe_2O_3.FeBO_3.24H_2O$*

* The high viscosities are due to the presence of a sufficient concentration of free glycerine, as the sol could not be dialysed long. The unstability of the sol also contributed towards this end

The amount of bound water per litre of the sol was calculated from the Hatschek's equation (cf. Mushran, Curr. Sci., 1945, **14**, 233).

The sols were coagulated cataphoretically as well as by $N/2$-KCl, centrifuged, and the p_H values of the supernatant aqueous layers were determined using the Hildebrand's hydrogen electrode. The following p_H values are recorded :

Sol A	7.32 (KCl-coagulated)	7.34 (cataphoretically coagulated)
Sol B	7.56 (KCl-coagulated)	7.60 (cataphoretically coagulated)

Sp. Conductivities of the Sols

The conductivities of the sols at various dilutions, at different temperatures and also on ageing have been investigated. The results are recorded in the following tables.

TABLE IIA

Sp. conductivity at different dilutions (30°)

Dilution.	Conductivity × 10⁴ mho.		Dilution.	Conductivity × 10⁴ mho.	
	Sol A.	Sol B.		Sol A.	Sol B.
Original sol (X)	5.21	57.59	Original sol X/2	2.70	40.39
5X/6	4.36	55.61	X/3	1.87	29.53
2X/3	3.55	51.47	X/6	0.94	17.80

TABLE IIB

Sp. conductivity on ageing (30°)

Dates.	Conductivity × 10⁴ mho.		Dates.	Conductivity × 10⁴ mho.	
	Sol A.	Sol B.		Sol A.	Sol B.
2-11-44	5.11	..	2-2-45	6.00	..
7-11-44	5.21	..	22-2-45	..	57.59
16-11-44	5.41	..	29-2-45	..	The sol settles down
20-12-44	5.67	..	12-3-45	6.08	..

TABLE II c

Sp. conductivity at different temperatures

	Sol A.			Sol B.	
Temp.	Sp. condy. × 10⁴mho.	Diff. per 5°.		Sp. condy. × 10⁴mho.	Diff. per 5°.
40°	6.30			69.98	
		0.49			5.99
35°	5.81			63.99	
		0.58			6.40
30°	5.23			57.59	
		0.47			6.40
25°	4.76			51.19	
		0.49			6.38
20°	4.27			44.81	
Temp. of zero conductance (extrapolated)	−22 0°			−16.5°	
Temp. coefficient per 1°	0.10			1.26	

From the above data it appears that sol A is fairly stable on dilution, as the conductivities of this sol are proportional to the dilutions. In the case of sol B, the conductivities are always higher than those computed on the basis of dilution. Marked hydrolysis of the sol B is thus indicated. The conductivities of the sols increase with age. The conductivity-temperature curves are straight lines. The temperatures of zero conductance of the sols range between −16.5° and −22°.

It will be of interest to study the temperature coefficients of the sols. The temperature coefficients and the conductivities at 35° are given below.

	Conductivity at 35°.	Temperature coefficient per 1°.
Sol A	5.81 × 10⁻⁴ mho	0.10
Sol B	63.99	1.26

The temperature coefficient of sol A is 1.72% of the conductance at 35° and of sol B is 1.97% of the conductance at 35°. The temperature coefficients are thus always less than 2% of the conductances at 35°.

Extinction Coefficients of the Sols

Extinction coefficients were determined by the Nutting's spectrophotometer at different dilutions and at different wave-lengths (X stands for the original undiluted sol).

TABLE III

	Sol A.					Sol B.		
Wave-lengths.	X.	$X/2$.	$X/4$.	$X/8$.	Wave-lengths.	X.	$X/2$.	$X/4$.
4800 Å.	3.80	1.90	0.95	0.48	4800 Å	2.92	1.70	0.95
5000	2.70	1.35	0.63	0.32	5000	2.46	1.41	0.81
5200	1.85	0.92	0.46	0.23	5200	2.03	1.15	0.66
5400	1.18	0.60	0.31	0.16	5400	1.61	0.97	0.51
5600	0.85	0.43	0.22	0 11	5600	1.20	0.78	0.41
5800	0.51	0.25	0.13	0.07	5800	0.82	0 50	0.27
6000	0.39	0.20	0.10	0.05	6000	0.55	0.39	0.22
6200	0.25	0.13	0.07	0.04	6200	0.43	0.32	0.19
6400	0.20	0.10	0.06	0.03				

From these data, it will be seen that in the case of sol A Beer's law is almost rigidly followed, *i.e.*, the extinction coefficients are almost proportional to the dilutions. In the case of sol B, the extinction coefficients are always greater than those computed on the basis of dilution. The hydrolysis of ferric borate at different dilutions has caused deviations in the extinction coefficient-dilution relationship. Our results on the conductivities at different dilutions (Table IIA) also show similar behaviour.

Coagulation of the Sols

In the following table are recorded the minimum amounts of electrolytes necessary to coagulate 1 c.c. of the sols in a total volume of 10 c.c., the time allowed in each case being 30 minutes.

TABLE IV

Electrolytes.	Amount necessary to coagulate.		Electrolytes.	Amount necessary to coagulate.	
	Sol A.	Sol B.		Sol A.	Sol B.
$N/2$-NaCl	1.70 c.c.	0.60 c c	$N/2$-KBr	1.50 c.c.	0.40 c.c.
$N/2$-KCl	1.50	0.40	$N/250$-Ba(NO$_3$)$_2$	1.80	0.60
			$N/250$-Sr(NO$_3$)$_2$	2.00	0.90
$N/2$-KNO$_3$	1.50	0.40	$N/250$-AlCl$_3$	1.20	0.30

The coagulating power of the ions thus fall in the following series :
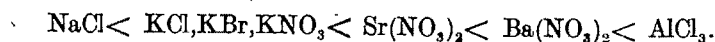
$$\text{NaCl} < \text{KCl}, \text{KBr}, \text{KNO}_3 < \text{Sr(NO}_3)_2 < \text{Ba(NO}_3)_2 < \text{AlCl}_3.$$

The effect of dilution on the coagulation values has also been investigated.

TABLE V

Total vol. $= 10$ c.c.

Electrolytes.	Vol. necessary to coagulate					
	Sol A			Sol B		
	1 c.c.	2 c.c.	3 c.c.	1 c.c.	2 c.c.	3 c.c.
$N/2$-NaCl	1.70	1.80	1 90	0.60	0.70	0.80
$N/2$-KCl	1.50	1.60	1 70	0.40	0.50	0.60
$N/2$-KNO$_3$	1.50	1.60	1.70	0.40	0.50	0.60

From Table V it is evident that the sols obey the Schulze-Hardy rule for the coagulation with electrolytes. They show the normal behaviour with dilution.

Positively Charged Ferric Borate Sols

It has been observed by previous workers (Prakash and Dhar, *loc. cit.*) that ferric chloride solutions dissolve a considerable amount of borax to give a positively charged sol of ferric borate. In Table VI are given our results on the composition of some positively charged ferric borate sols.

Sol A was prepared by mixing 20 c.c. of ferric chloride solution (69.84 g. of Fe$_2$O$_3$ per litre), 80 c.c. of 8% borax solution. The total volume was kept 100 c.c The sol was dialysed for two days.

Sol B was prepared by mixing 20 c.c. of the same ferric chloride solution and 70 c.c. of 8% borax solution. The total volume was kept 90 c.c. The sol was dialysed for two days.

Estimations for iron and borate were made in the same manner as in the case of the negatively charged ferric borate sols.

TABLE VI

Per litre.	Sol A.	Sol B.
Total iron	8.7495 g.	9.0220 g
Combined borate (H_3BO_3)	1.9200	1.7360
Combined iron	1.7360	1.5680
Free iron	7.0135	7.4540
Viscosity of sol	0.00840	0.00838
Water, bound	0.08545	0.07290
Empirical formula	$2Fe_2O_3.FeBO_3$. 0.2 H_2O	$5Fe_2O_3.2FeBO_3$, 0.3 H_2O

Sol A contained 2.3640 g. of chloride ions per litre
Sol B contained 2.1276 g. of chloride ions per litre

DISCUSSION

It is difficult to say if the ferric borate precipitated by the reaction between borax and ferric chloride solutions, has a composition corresponding to *ortho-*, *meta-*, or *tetra-*borate. Similar anomalous behaviour occurs in the case of other borate salts precipitated when a borax solution is used. According to Hartley and Ramage, (*J. Chem. Soc.*, 1893, **63**, 129) a bulky precipitate was obtained by adding a solution of manganese sulphate slowly to a solution of borax at 22.4°. This precipitate on washing and drying in *vacuo* furnished a bulky brownish white powder. Analysis of this substance corresponded with the composition of monohydrated manganese tetrahydro-*ortho*borate. The reaction was represented as :

$$Na_2B_4O_7 + 2MnSO_4 + 5H_2O = Na_2SO_4 + H_2SO_4 + 2MnH_4(BO_3)_2.$$
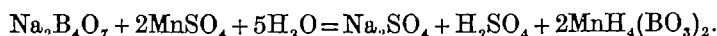
The same compound was produced by treating borax with sodium hydroxide and manganese sulphate :

$$Na_2B_4O_7 + 2NaOH + 3H_2O + 2MnSO_4 = 2Na_2SO_4 + 2MnH_4(BO_3)_2.$$

On the analogy of manganese *ortho*borate salt, thus precipitated, we may presume the precipitation of ferric *ortho*borate when borax is added to ferric chloride solution. At any rate, the negatively charged ferric borate sol is likely to have this composition when it is peptised with caustic alkali. The reaction may be represented as follows :

$$4FeCl_3 + Na_2B_4O_7 + 10NaOH = 4FeBO_3 + 12NaCl + 5H_2O.$$
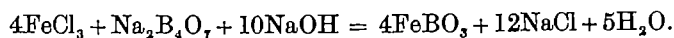
For the positively charged sol, one can assign either a *meta*borate or a tetraborate constitution. In such cases, ferric borate is precipitated according to one of the following equations :

(*i*) $4FeCl_3 + 3Na_2B_4O_7 + 3H_2O = 4Fe(BO_2)_3 + 6NaCl + 6HCl$

(*ii*) $2FeCl_3 + 3Na_2B_4O_7 = Fe_2(B_4O_7)_3 + 6NaCl.$
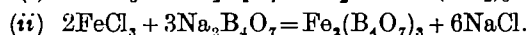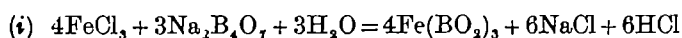
However, for comparison, we have given the composition of positively charged sols also in the form of *ortho*borate. The general composition of ferric borate may be expressed by a formula : $xFe_2O_3. yB_2O_3.zH_2O$.

During the course of dialysis (specially in the presence of alkali) ferric borate is hydrolysed to substances of various compositions showing ultimately the following equilibria :

$$xFeBO_3 \longleftrightarrow x'FeBO_3.y'Fe_2O_3 \longleftrightarrow y''Fe_2O_3.$$
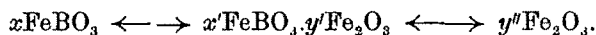
The *ortho*boric acid being tribasic, ferric borate may have dihydrogen and monohydrogen compositions also :

$$FeBO_3 \longleftrightarrow Fe_2(HBO_3)_3 \longleftrightarrow Fe(H_2BO_3)_3.$$
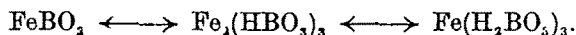
These substances also gradually hydrolyse giving ultimately a mixed composition of ferric borate and ferric oxide.

The compositions of various negatively and positively charged ferric borate sols studied in this paper are :

Negatively charged :   (i) $11Fe_2O_3. 2FeBO_3.3H_2O$,   (ii) $5Fe_2O_3. FeBO_3.24H_2O$

Positively charged :   (i) $2Fe_2O_3. FeBO_3.0.2H_2O$,   (ii) $5Fe_2O_3.2FeBO_3.0.3H_2O$.

From the compositions given here it is clear that the positively charged sols contain proportionately a higher content of ferric borate.

CONCLUSION

We have studied in details the various characteristics of the negatively charged ferric borate sol and from the results recorded in the foregoing tables the following observations may be summarised :

1.   The electrical conductivity of the sol, peptised in presence of glucose, is approximately proportional to the dilution, whilst in the case of the sol peptised in presence of glycerine, at no stage is it proportional to the dilution.   Marked hydrolysis of the glycerine sol on dilution is thus indicated.

2.   The electrical conductivities of both the glucose and the glycerine sols are linear functions of temperatures.   The temperatures of zero conductance lie between $-16.2°$ and $-22°$.

3.   The temperature coefficients of conductivity of the sols are always less than 2% of the conductances at $35°$.

4.   Effect of ageing on the conductivity of the glucose sols shows an increase in conductivity with ageing.   The sol peptised in presence of glycerine is very unstable and is thrown out in the course of a week.

5.   The changes in the extinction coefficients with dilution show that whilst Beer's law is obeyed in the case of the glucose sol, it is not obeyed in-the case of the glycerine sol.   The extinction coefficients of the glycerine sol do not decrease with dilution in the same proportion indicating hydrolysis of this sol on dilution.

6.   The p_H values of the dispersion medium lie between 7.32 and 7.60 showing that the sols are slightly basic owing to the stabilising hydroxide ions.

7.   The sols obey the Schulze-Hardy rule for the coagulation with electrolytes. They show the normal behaviour with dilution.

SYNTHETIC INVESTIGATIONS ON STEROLS, BILE ACID, HORMONE, ETC. PART IV. SYNTHESIS OF 9-KETO-2 : 13-DIMETHYL-Δ^{10}-1 : 2-*CYCLO*PENTANO-PERHYDROPHENANTHRENE

BY P. BAGCHI AND D. K. BANERJEE

A synthesis of *cyclo*pentanoperhydrophenanthrene derivative with the angular methyl groups in proper position has been described. Possibility of the formation of vitamin-D_1 ring system from the above perhydrophenanthrene derivative has also been indicated.

During a study of two addition products of vitamin-D_3, Windaus and Thiele (*Annalen*, 1935, **521**, 160) observed that dihydro derivatives of the above adducts, obtained by the saturation of the double bond in the side chain, on ozonisation yielded a saturated ketone of the composition $C_{19}H_{34}O$ [VIII, R = —CH(CH₃)·CH₂.CH₂,·CH(CH₃)—CH(CH₃)—CH₃]. Later Dimroth and Jonsonn (*Ber.*, 1941, **74B**, 520) also obtained a stereoisomer of the same ketone by a different method. In view of the recent methods developed by different workers (Aldersley, Burkhardt, Gillam and Hindley, *J. Chem. Soc.*, 1940, 10 ; *cf.* Aldersley and Burkhardt, *ibid.*, 1938, 545 ; Milas and Anderson, *J. Amer. Chem. Soc.*, 1939, **61**, 2534 ; Dimroth *et al.*, *Ber.*, 1942, **75B**, 180, 322, 326, 510, 582, 1263 ; *ibid.*, 1943, **76B**, 317) for the building up of ring systems possessing conjugated double bonds peculiar to vitamin-D_2 and D_3, the importance of the synthesis of the type of ketone (VIII) can hardly be over-estimated (*cf.* Barchmann and Struve, *J. Amer. Chem. Soc.*, 1941, **63**, 1262, 2589). As a preliminary study we have carried out the synthesis of 8-methyl-0 : 3 : 4-bi*cyclo*nonane-4-one (VIII, R = H) by the following method.

Potassio or sodio derivative of ethyl 2-methyl-2-carbethoxy*cyclo*pentylcyanoacetate has been condensed with ethyl β-bromopropionate and the resulting ethyl β-carbethoxy-ethyl-(2-methyl-2-carbethoxy*cyclo*pentyl)cyanoacetate (I) is hydrolysed by prolonged refluxing with concentrated hydrochloric acid to yield α-(2-methyl-2-carboxy*cyclo*pentyl)-glutaric acid (II, R = H). Triethyl ester (II, R = Et) smoothly undergoes Dieckmann's condensation in presence of metallic sodium to give ethyl 8-methyl-0:3 : 4-bi*cyclo*nonane-7-one-4 : 6-dicarboxylate (III). For the subsequent hydrolysis, the above β-ketonic ester is refluxed in the crude state with 20% sulphuric acid and the resulting 8-methyl-0 : 3 : 4-bi*cyclo*nonane-7-one-4-carboxylic acid (IV), on purification by distillation in vacuum, solidified. The keto-acid (IV) is next reduced by refluxing with zinc amalgam and concentrated hydrochloric acid. 8-Methyl-0 : 3 : 4-bi*cyclo*nonane-4-carboxylic acid (V), thus obtained, is converted through its acid chloride, followed by bromination and esterification, into ethyl 8-methyl-0 : 3 : 4-bi*cyclo*nonane-4-bromo-4-carboxylate (VI). The above bromo-ester, on being refluxed with alcoholic potash, yields 8-methyl-0 : 3 : 4-bi-*cyclo*nonane-Δ^4-ene-4-carboxylic acid (VII) as an oil. 8-Methyl-0 : 3 : 4-bi*cyclo*nonane-4-one (VIII, R = H) is obtained by treatment of this unsaturated acid with sodium azide and sulphuric acid in chloroform solution according to the method of Oesterlin (*Z. angew. Chem.*, 1932, **45**, 536 : *cf.* Von Braun, *Annalen*, 1931, **490**, 125).

CH₃
$\Big\langle$—CO₂Et + Br.CH₂.CH₂.CO₂Et → .
—CH(CN).CO₂Et

CH₃
$\Big\langle$—CO₂Et →
—C(CN).CO₂Et
|
(I)   CH₂.CH₂.CO₂Et

CH₃
$\Big\langle$—CO₂R
—CH.CO₂R → .
|
CH₂.CH₂.CO₂R

(II, R = H, Et)

O CH₃
‖
EtO₂C— →
CO₂Et
(III)

O CH₃
‖
→
CO₂H
(IV)

CH₃
|
CO₂H
(V)

CH₃
→
Br CO₂Et
(VI)

CH₃
→
CO₂H
(VII)

CH₃
R
→
‖
O
(VIII)

CH₃   CH₃ CH₃
| | |
(R = H, —CH.CH₂.CH₂—CH—CH.CH₃).
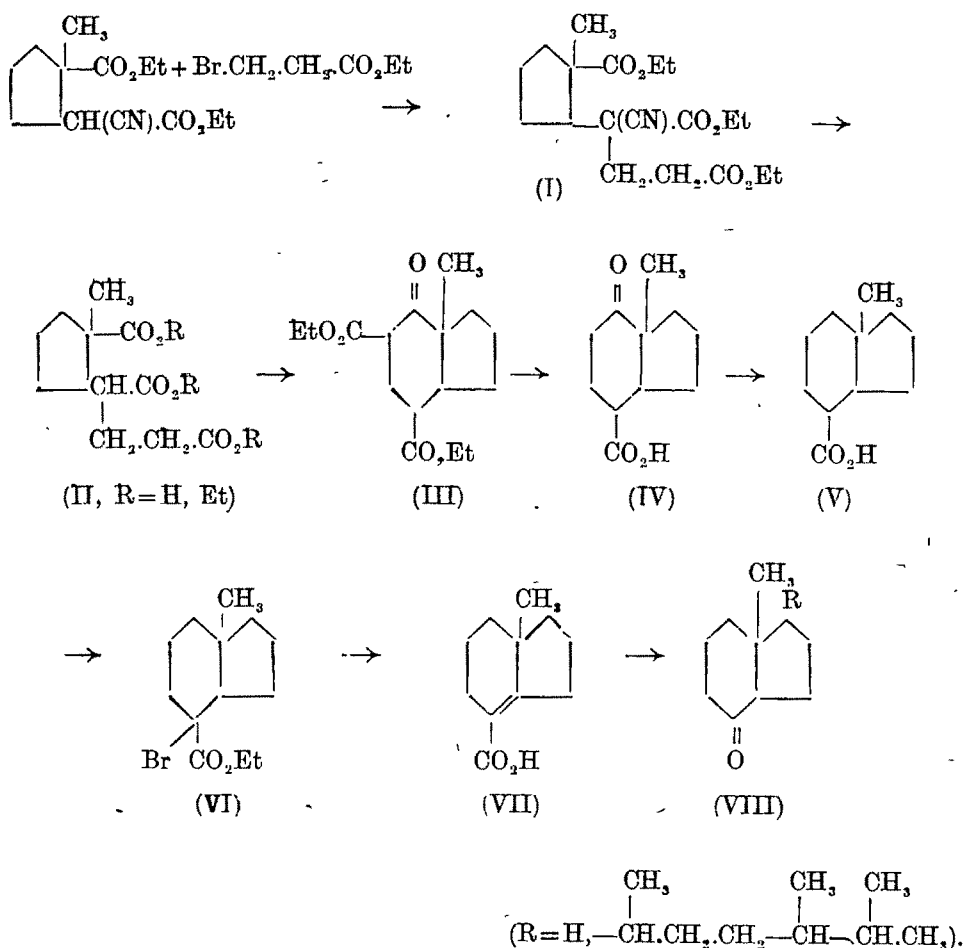
Among the different methods developed for the preparation of vitamin-D₂ type of compound, mentioned above, few were successful in incorporating the required conjugated system. We, however, considered that a synthesis of the ergosterol nucleus (X) should furnish us with the parent substance, which might easily be converted into vitamin-D₂ type of compounds by irradiation, just as ergosterol and dehydrocholesterol are converted into vitamin-D₂ and D₃ respectively (Lettre, *Annalen*, 1934, **511**, 280 ; Dimroth, *Ber.*, 1937, **70**, 1631 ; Windaus and Langer, *Annalen*, 1933, **508**, 105 ; Windaus, Lettre and Schenck, *Annalen*, 1935, **520**, 98 ; Windaus, Schenck and Werder, *Z. physiol. Chem.*, 1936, **241**, 100 ; Grab, *ibid.*, 1936, **243**, 63). With this end in view we have condensed 8-methyl-0 : 3 : 4-bi*cyclo*nonane-4-one with methyl acetyl*cyclo*hexene in presence of potassium *iso*propylate in pyridine solution (Hüber, *Ber* , 1938, **71**, 725) and 9-keto-2:13-dimethyl-Δ¹⁰-1 : 2-*cyclo*pentano-perhydrophenanthrene (IX) is obtained in 40% yield as a yellow oil with characteristic odour. It is our intention to convert (IX) into the ergosterol nucleus following the reaction indicated below. Further work is also in progress to prepare the ketone of the type (VIII) with the *iso*octyl side chain in the proper position.

(IX)

(X)   (XI)
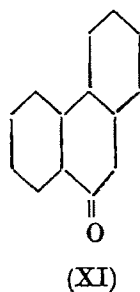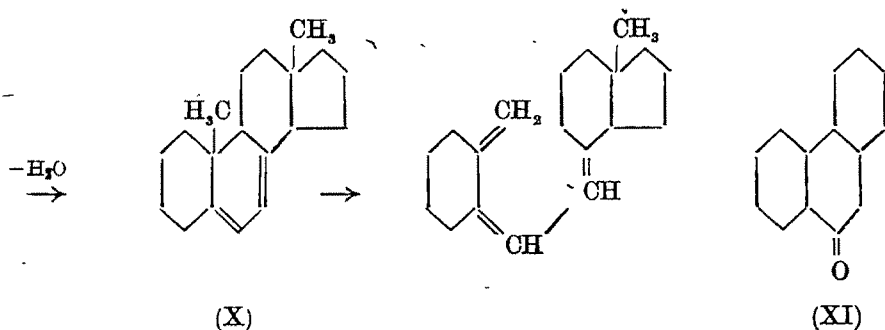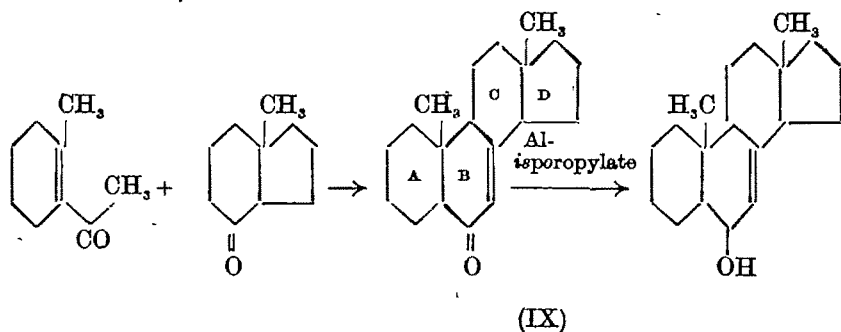
From our previous experience (Banerjee, *Science & Culture*, 1944, **9**, 456; Bagchi and Banerjee, to be published in Part V later) it seems that the locking of the rings C and D is *cis*. Previously Linstead *et al*. (*J. Amer. Chem. Soc.*, 1942, **64**, 2014) have shown that the perhydrophenanthrene derivative (XI), obtained by the condensation of *cyclo*hexanone and acetyl*cyclo*hexene, followed by catalytic reduction, possesses *trans-anti-trans* configuration *i.e.*, that present in the cholestane system. From the analogy of reaction, it is probable that the rings A, B and C in the tetracyclic ring system (IX) possess similar configuration at C_{12} C_{13} and C_{14}.

EXPERIMENTAL

Ethyl β-Carbethoxyethyl-(2-methyl-2-carbethoxycyclopentyl)-cyanoacetate.—(*a*) Ethyl 2-methyl-2-carbethoxy*cyclo*pentylcyanoacetate (74.5 g., Bagchi and Banerjee, Part **V**, under publication) was slowly dropped into a cooled solution of sodium ethoxide from sodium (6.5 g.) and absolute alcohol (100 c.c.). The mixture was allowed to stand for a few hours and then to it in the cold was added ethyl β-bromopropionate (53 g.) and was left overnight. The reaction mixture was refluxed on a water-bath for 24 hours and was worked up in the usual way. The condensation product, which was obtained as a viscous oil, boiled at 195-97°/4-5 mm., yield 76 g., while unreacted cyano-ester (14.5 g.) was recovered. (Found : C, 62.5; H, 7.8. $C_{19}H_{29}O_5N$ requires C, 62.1; H, 7.9 per cent).

(*b*) Ethyl 2-methyl-2-carbethoxy*cyclo*pentylcyanoacetate (13 g.) was slowly dropped in cooled dry xylene (50 c.c.) containing potassium dust (1.8 g.) and left overnight. Ethyl

β-bromopropionate (9 g.) was added to it in the cold and the whole was refluxed in an oil-bath for 20 hours, yield of the condensation product was 13 g.

Ethyl α-(2-Methyl-2-carbethoxycyclopentyl)-glutarate.—The   above   condensation product (118 g.) was hydrolysed by prolonged refluxing with an excess of concentrated hydrochloric acid as before (Bagchi and Banerjee, *loc. cit.*). A small portion of the tri-carboxylic acid crystallised out on cooling and was purified by recrystallisation from dilute hydrochloric acid (charcoal) when it melted at 189-92°. (Found : C, 55.9 ; H, 7.12. $C_{12}H_{18}O_6$ requires C, 55 8 ; H, 6.99 per cent). Main bulk of the acid solution was evaporated to dryness on a water-bath in a basin and the crude product mixed with ammonium chloride was esterified by the alcohol-sulphuric acid method. It was worked up in the usual way, when the tricarboxylic ester (76 g.) was obtained boiling at 175-176°/6 mm. On re-esterification of the acidic product obtained from the alkaline wash, further 17.5 g. of the tricarboxylic ester were obtained. (Found : C, 62.87 ; H, 8.87. $C_{18}H_{30}O_6$ requires C, 63.15 ; H, 8.78 per cent).

Ethyl 8-Methyl-0 : 3 : 4-bicyclononane-7-one-4 : 6-dicarboxylate.—Tricarboxylic ester (II, R = Et ; 32 g.) was refluxed in benzene solution with sodium dust (4.3 g.) until whole of the metallic sodium disappeared (*ca.* 3 hours). On working up in the usual manner, 18 g. of ethyl 8-methyl-0 : 3 : 4-bicyclononane-7-one-4 : 6-dicarboxylate were obtained, b.p. 200°/12 mm. It gave an intense ferric chloride coloration in an alcoholic solution. (Found : C, 65.10 ; H, 8.34. $C_{16}H_{24}O_5$ requires C, 64.86 ; H, 8.1 per cent).

8-Methyl-0 : 3 : 4-bicyclononane-7-one-4-carboxylic Acid.—For the hydrolysis of the above β-ketonic ester, Dieckmann product obtained from 76 g. of the tricarboxylic ester (II, R = Et) after complete removal of solvents, was hydrolysed by refluxing with 500 c.c. of 20% sulphuric acid for 16 hours. After extraction with ether, the solvent was removed and the product was purified by distillation in vacuum (b.p. 182°/5 mm.) when it solidified, m.p. 95-96°, yield 30-32 g. (Found : C, 66.7 ; H, 8.2. $C_{11}H_{16}O_3$ requires C, 67.3 ; H, 8.2 per cent).

The *semicarbazone,* prepared in the usual manner, crystallised from dilute alcohol and melted at 217°. (Found : C, 56.7 ; H, 7.4. $C_{12}H_{19}O_3N_3$ requires C, 56.9 ; H, 7.5 per cent).

8-*Methyl*-0 : 3 : 4-bicyclononane-4-carboxylic   *Acid.*—8-Methyl-0 : 3 : 4-bicyclononane-7-one-4-carboxylic acid (40 g.) was heated under a reflux condenser with zinc amalgam (400 g., Bachmann, Carmack and Safir, *J. Amer. Chem. Soc.,* 1941, **63,** 1683) and concentrated hydrochloric acid (200 c.c.) and toluene (10 c.c.) for 30 hours with addition (8 times) of further hydrochloric acid (20 c.c.) at regular interval. The cold reaction mixture was thoroughly extracted with ether and the ethereal extract was washed with water, dried and ether removed. On fractionation, 28 g. of a product boiled at 156-158°/8 mm. (Found : C, 71.8 ; H, 9.6. $C_{11}H_{18}O_2$ requires C, 72.5 ; H, 9.9 per cent).

8-*Methyl*-0 : 3 : 4-bicyclononane-Δ⁴-ene-4-carboxylic   *Acid.*—8-Methyl-0 : 3 : 4-bicyclo-nonane-4-carboxylic acid (27 g) was converted into its acid chloride by refluxing with thionyl chloride (27 c.c) and dry benzene (50 c.c.) for 4 hours. Excess of thionyl chloride and benzene were emoved under reduced pressure, and the residue on distillation in

vacuum boiled at 112-14°/7 mm., yield 29 g. It was then transferred to a flask with a little carbon tetrachloride and was then heated on a water-bath under a reflux condenser with the addition of a pinch of red phosphorus and bromine (10 c.c.) until the colour of bromine almost disappeared. Absolute alcohol (100 c.c.) was very cautiously added to the reaction mixture in the cold, with frequent swirling and then the whole was refluxed for 2 hours. On cooling, the alcoholic solution was poured into water and the heavy oil, which separated at the bottom, was thoroughly extracted with ether. The ethereal layer was washed with water, soda solution and again with water. Ether was removed, and on distillation, ethyl 8-methyl-0 : 3 : 4-bicyclononane-4-bromo-4-carboxylate (34 g.) boiled at 142-44°/8 mm. (Found : C, 53.4 ; H, 6.9. $C_{13}H_{21}O_2Br$ requires C, 53.99 ; H, 7.2 per cent).

The above bromo-ester was next refluxed with an alcoholic potassium hydroxide solution (40 g. in 200 c.c. alcohol) for 4 hours, poured into a basin and the alcohol was removed on a boiling water-bath with the addition of distilled water. The cooled alkaline solution was acidified after it was extracted with ether. The acidic product was thoroughly extracted with ether. After removal of ether the residue boiled at 161°/8 mm., yield 18 g. (Found : C, 72.0 ; H, 8.8. $C_{11}H_{16}O_2$ requires C, 73.3 ; H, 8.9 per cent). The product showed the presence of a trace of bromine by Beristein's test.

8-Methyl-0 : 3 : 4-*bicyclononane*-4-*one*.—The unsaturated acid (VII, 17 g.), concentrated sulphuric acid (20 c.c.) and dry chloroform (80 c.c.) were taken in a three-necked flask fitted with a mercury-sealed stirrer. Through one of the necks passed a thermometer fitted with a cork, while the third one was provided with a calcium chloride guard tube. Sodium azide (8 g.) was added in small portions at such a rate that the temperature of the reaction mixture remained between 40° and 50°. Stirring was continued even after the addition was complete until the frothing that occurred during the reaction completely subsided. The reaction mixture was then diluted with water and refluxed for 2 hours, after replacing the guard tube with an upright condenser. On cooling, it was thoroughly extracted with ether, and the ethereal layer was washed with water, soda solution and with water again. Ether was removed and the residue on distillation boiled at 92-94°/8 mm. leaving a small quantity of a higher boiling product, yield 6 g. (Found : C, 78.2 ; H, 10.4. $C_{10}H_{16}O$ requires C, 78.9 ; H, 10.5 per cent).

The *semicarbazone* was prepared in the usual way and was crystallised from dilute alcohol, m.p. 185-86°. (Found : C, 63.10 ; H, 9.16. $C_{11}H_{19}ON_3$ requires C, 63.16 ; H, 9.09 per cent).

9-Keto-2 : 13-*dimethyl*-Δ^{10}-1 : 2-*cyclopentano-perhydrophenanthrene*.—Potassium dust (1.9 g.) under dry ether (50 c.c.) was treated with dry *iso*propyl alcohol (11.2 c.c.) in the cold, when a clear solution resulted within a short time. The ethereal solution of potassium *iso*propylate was cooled in an ice-bath and to it was added dropwise a solution of 8-methyl-0 : 3 : 4-bicyclononane-4-one (5.9 g.), methylacetylcyclohexene (5.3 g. ; Ruzicka, Koolhass and Dind, *Helv. Chim. Acta*, 1931, **14,** 1151) in dry pyridine (20 c.c.) and the solution was left in a closed flask for 2 days. After refluxing for 1 hour the cooled solution was treated with cold dilute hydrochloric acid and was thoroughly extracted with ether. After removal of ether, the residue was fractionated when 3 g. of a product boiled

at 153-57° below 1 mm. and 6.3 g. of unreacted products were recovered. (Found : C, 82.7 ; H, 10.5. $C_{19}H_{28}O$ requires C, 83.8 ; H, 10.3 per- cent).

A saturated aqueous solution of semicarbazide hydrochloride and sodium acetate and the above unsaturated ketone were made clear with the addition of absolute alcohol and warming and left at the room temperature for several days, when the crystals of semicarbazone separated out slowly. These were collected, washed with water and then crystallised from dilute alcohol, m.p. 164-66° (shrinks at 158°). (Found : C, 72.8 ; H, 9.3. $C_{20}H_{31}ON_3$ requires C, 72.9 ; H, 9.4 per cent).

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ABSORPTION OF IODINE BY HYDROXYLAMINE SALTS. PART II. EFFECT OF NEUTRAL SALTS, BASIC SALTS AND ACIDS

By R. K. Trivedi, C. C. Shah and D. K. Patel

In the presence of either neutral salts, basic salts or acids the iodine absorbed increases rapidly and reaches a maximum in about 2-10 minutes after which iodine appears to be liberated at a higher rate than that at which it is absorbed and hence the apparent absorption of iodine falls In neutral solution, the liberation of iodine takes place slowly, although as a general rule neutral salts have no appreciable effect on the course of this reaction The absorption of iodine appears to be fairly rapid and continuously increases with time in the presence of basic salts In the presence of mineral acids, the primary absorption of iodine is very small, being only about 1/5th of that required in the case of neutral salts The liberation of iodine in the second stage, under these conditions, is more rapid In the presence of acetic acid, the absorption is similar to that in the case of neutral salts The absorption of iodine is slightly more in an atmosphere of carbon dioxide than under ordinary conditions.

In Part I (*J. Indian Chem. Soc.*, 1946, **23**, 361) it was shown that the quantity of iodine absorbed by hydroxylamine salt solution varied considerably with (*i*) concentration, (*ii*) temperature and (*iii*) time. In this part are recorded the results of a study of the influence of acids, basic salts and neutral salts on the rate and degree of absorption.

Experimental

Effect of Acids on the Course of the Reaction

Mineral Acids.—In the presence of mineral acids the primary absorption of iodine was very small as shown in Table I below. It was almost one fifth of that required in the case of neutral solution (*vide* Table I, Part I) and the liberation of iodine due to secondary reactions was more rapid.

Table I

Vol. of $N/100$ iodine soln. absorbed at 35° by 5 c.c. solution of hydroxylamine salts at 200 c.c. dilution of 0.02 N acid when 25 c.c. of $N/100$ iodine soln. were added every time.

Time.	$NH_2OH.HCl$ in HCl $M/100$	$(NH_2OH)_2.$ H_2SO_4 in H_2SO_4 $M/200$	$NH_2OH.HNO_3$ in HNO_3 $M/100$	Time.	$NH_2OH.HCl$ in HCl $M/100$	$(NH_2OH)_2.$ H_2SO_4 in H_2SO_4 $M/200$	$NH_2OH.$ HNO_3 in HNO_3 $M/100$
1 min.	1.4 c.c.	1.6 c.c.	1.6 c.c.	10 min.	2.7 c.c.	5.0 c.c.	2.6 c.c.
3	3.4	4.2	3.8	15	—0.8	—0.9	—0.7
5	4.2	5.4	4·4	30	—3.1	—4.5	—6.9

Acetic Acid.—In the presence of acetic acid the absorption was similar to that in the case of neutral solution (see Table I, Part I). The maximum absorption was almost equal to, though a little less, than what occurred in the absence of any other substance as shown in Table II.

<div align="center">TABLE II</div>

Vol. of $N/100$ iodine soln. absorbed at 35° by 5 c.c. soln. of hydroxylamine salts at 200 c.c. dilution of 0.02 N acetic acid when 25 c.c. of $N/100$ iodine soln. were added every time.

Time.	$NH_2OH.HCl$ $M/100$	$(NH_2OH)_2.$ H_2SO_4 $M/200$	$NH_2OH.$ HNO_3 $M/100$	Time.	$NH_2OH.HCl$ $M/100$	$(NH_2OH)_2.$ H_2SO_4 $M/200$	$NH_2OH.$ HNO_3 $M/100$
1 min.	12.3 c.c.	12.5 c.c.	13.4 c.c.	10 min.	17.0 c c.	16.9 c.c.	17.4 c c.
3	16.4	16.4	17.0	15	16.4	16.3	17.1
5	17.3	17.2	17.7	30	14.8	14.6	15.4

Effect of Basic Salts.—The absorption of iodine continually increased with time in the case of basic salts but the basic salts themselves absorbed iodine and it was not possible to differentiate this absorption by basic salts from that of hydroxylamine, though it might be said that in this case the absorption was fairly rapid.

Effect of Neutral Salts.—It may be said as a general rule that neutral salts have no appreciable effect on the course of the reaction as shown in Table III below. The extent of effect on the primary and secondary reactions (Part I, Table I) was, however, almost the same, so that their main effect was to shift the maxima with respect to time. The negative ions: chloride, sulphate and nitrate, behaved similarly *i.e.* they had either no effect on the course of the reaction or the extent of the effect of all the three was the same (Table III). Sodium and potassium ions, however, differ in their effect on the reaction as shown below. The nature and extent of this effect are dependent on the experimental conditions.

<div align="center">TABLE III</div>

Vol of $N/100$ iodine soln. absorbed at 35° by 5 c.c. soln. of hydroxylamine salts at 200 c.c. dilution of 0.02N sodium and potassium salts when 25 c.c. of $N/100$ iodine solution were added every time.

Time.	$M/100$-$NH_2OH.HCl$ in NaCl.	KCl.	$M/200$-$(NH.OH)_2.H_2SO_4$ in Na_2SO_4.	K_2SO_4.	$M'100$-$NH_2OH.HNO_3$ in NaNO_3.	KNO_3.
1 min.	14.15 c.c.	14.15 c.c.	16.2 c.c.	15.6 c.c.	14.0 c.c.	15.3 c.c.
3	17.05	17.45	18.35	17.35	16.9	17.7
5	17.60	17.80	18.50	17.50	17.2	18.35
10	17.55	17.70	18.45	17.45	17.0	18.20
15	17.40	17.55	18.40	17.40	16.9	18.15
30	16.60	16.75	18.15	17.15	16.3	17.10

Effect of Dilution on the Absorption of Iodine in the presence of Neutral Salts and Acids.—Either in the case of mineral acids or in presence of acetic acid, the quantity of iodine absorbed increased with dilution and tended to be constant at high dilutions as shown in Part I. The only effect of these acids was that the maximum quantity of iodine absorbed was less than that absorbed in neutral solutions, being remarkably less in the presence of mineral acids. In presence of sodium and potassium salts as well, the general behaviour was the same as shown in Part I, Table II. Dilution increased the absorption tending to be constant at high dilutions (*cf*. Part I. Table II).

Effect of the Amount of Iodine on its Absorption in presence of Neutral   Salts and Acids.—In the presence of mineral acids, acetic acid, sodium salts and potassium salts, the absorption of iodine increased with the quantity of iodine (concentrated) added tending to be constant when the quantity added was 2 to 3 times more than what was observed to be absorbed in neutral solutions.

Effect of Concentration of Acids on the Absorption of Iodine.—In the presence of mineral acids, iodine was rapidly liberated after a very small initial absorption (Table IV). When the strength of acid was 0.4 N, the duration of absorption was apparently so short that no iodine appeared to have been absorbed. The effect of increasing amounts of acetic acid on the absorption of iodine was not so marked as in the case of mineral acids as shown below.

TABLE IV

Vol. of $N/100$ iodine soln. absorbed at 35° by 5 c.c. soln. of hydroxylamine salts at different concentrations of the acids at 200 c.c. dilution when 25 c.c. of $N/100$ iodine soln. were added every time.

Conc.	$M/100$-$NH_2OH.HCl$ in presence of		$M/200$-$(NH_2OH)_2.H_2SO_4$ in presence of		$M/100$-$NH_2OH.HNO_3$ in presence of	
	HCl.	CH_3COOH.	H_2SO_4.	CH_3COOH.	HNO_3.	CH_3COOH.
0.005 N	10.8 c.c.	17.85 c.c.	11.3 c.c.	17.6 c.c.	11.2 c.c.	17.5 c.c.
0.01	7.4	17.65	8.25	17.25	7.7	17.5
0.02	4.2	17.30	5.4	17.25	4.4	17.4
0.05	1.5	17.05	5.25	17.05	1.35	17.2
0.1	0.7	16.55	1.05	16.1	0.3	16.9
0.4	0.0	14.95	0.4	13.8 ⎰ Liberates I	⎰ 16.25
1.0	..	..	0.15	11.0 ⎱ from KI	⎱ 14.3

Effect of Concentration of Sodium and Potassium Salts.—Both these ions have an influence on the absorption of iodine.   The nature and the extent of this effect are dependent on the experimental conditions (Table V).

TABLE V

Vol. $N/100$ iodine soln. absorbed at 35· by 5 c.c. soln. of hydroxylamine salts at different concentrations of the neutral salts at 200 c.c. dilution when 25 c.c. of $N/100$ iodine soln. were added every time.

Conc.	$M/100$-$NH_2OH.HCl$ in presence of		$M/200$-$(NH_2OH)_2.H_2SO_4$ in presence of		$M/100$-$NH_2OH.HNO_3$ in presence of	
	NaCl.	KCl.	Na_2SO_4.	K_2SO_4.	$NaNO_3$.	KNO_3.
0.005 M	17.8 c.c.	18.15 c.c	18.0 c.c.	17.3 c.c.	16.9 c.c.	18.25 c.c.
0.01	17.7	18.0	18.25	17.45	16.95	18.3
0.02	17.6	17.8	18.5	17.5	17.2	18.35
0.05	17.4	17.7	18.4	17.6	17.3	18.35
0.1	17.25	17.65	18.15	17.4	17.35	18.55
0.4	17.1	17.55	..	.	17.4	18.6

Effect of Temperature on the Reaction in the presence of Neutral Salts and Acids.— Either in presence of acids or neutral salts, the rate of absorption of iodine and

the quantity of iodine absorbed increased rapidly as the temperature was raised. The general trend of absorption and reaction are similar to that in the neutral solution as shown in Part I.

Effect. of CO_2 *on the Absorption of Iodine.*—The absorption of iodine was slightly more in an atmosphere of carbon dioxide than in air. This may be due to the fact that the liberation of iodine by secondary reactions is minimised (*cf.* Table VI given below with Table I in Part I).

<div align="center">

TABLE VI

</div>

Vol. of $N/100$ iodine soln. absorbed at $35°$ by 5 c.c. soln. of hydroxylamine salts in an atmosphere of CO_2 at 200 c.c. dilution when 25 c.c. of $N/100$ iodine soln. were added every time.

Time.	$NH_2OH.HCl$ $M/100$	$(NH_2OH)_2.$ H_2SO_4 $M/200$	$NH_2OH.HNO_3$ $M/100$	Time.	$NH_2OH.HCl$ $M/100$	$(NH_2OH)_2.$ H_2SO_4 $M/200$	$NH_2OH.$ HNO_3 $M/100$
1 min.	14.4 c.c.	14.4 c.c.	14.5 c.c.	10 min.	17.7 c.c.	17.9 c.c.	17.5 c.c.
3	17.5	17.7	17.4	15	17.2	17.6	17.3
5	18.0	18.1	17.8	30	16.4	16.9	16.7

Experimental details were the same as carried out in Part I. The reaction in an atmosphere of carbon dioxide was carried out by passing a current of CO_2 in the reaction bottles for five minutes.

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THE COMPONENT FATTY ACIDS AND GLYCERIDES OF THE SEED FAT OF *MANGIFERA INDICA* (MANGO)*

BY S. P. PATHAK, B. G. GUNDE AND N. N. GODBOLE

Component fatty acids and glyceride structure of the seed fat of *Mangifera Indica* have been studied. The fatty acids comprise myristic (0.69%), palmitic 8.83%), stearic (33.96%), arachidic (6.74%) and oleic (49.78%). Mango fat comprises fully saturated glycerides (14.2%), mono-oleo-glycerides (24.2%), di-oleoglycerides (60.8%) and tri-unsaturated (0.8%)-

Mangifera Indica (N. O. Anacardiacae), commonly known as mango, is a large tree, indegenous to India and occurs almost every where on the plains and extensively cultivated for its fruits.

In general, there are two types of mango trees, one of which is grown from the seed, called " Tukhmi " and the other grown by grafting called " Kalmi " There are, however, several varieties in mango, each one differing from the other in size, colour, taste and flavour.

The kernel of the seed, which is grey-white in colour, contains about 12% of solid fat. No analytical data about the component fatty acids of the fat etc., are available except a few characteristics which were determined long ago by Peckolt (*Ber. phar. Ges.*, 1898, **8**, 167), Jumelle (" les Huilles vegetable ", 1921) and Sack (*Pharm. Weekbl.*, 1911, 13 ; *Apoth. Z.*, 1911, **26**, 302) are given below :—

Butyro No at 48°	..	..	..	48.4
Acid value	..	..	..	12.3
Saponification value	..	..	..	175.0
Iodine value	..	..	..	30.0 to 54.5
R.M value	..	..	..	0.2

With a view to studying quantitatively the component fatty acids, as well as the glyceride structure of the fat and also to see if it can be commercially exploitable, the present study was undertaken.

Methods of analysis, as developed by Hilditch and his collaborators, have been followed.

EXPERIMENTAL

For the present study kernels from the mangoes of a tree of *Tukhmi* variety were taken. The kernels were well dried, powdered and extracted with carbon tetrachloride in a Soxhlet's extractor.

6.5 Kg. of the kernels thus extracted gave 662 g. of a solid fat (11.8%) having an acid value of 20.1 and m.p. 40.5°. Since the glyceride structure was to be studied, the fat was washed with a 10% solution of potassium carbonate to remove the free fatty acid present. The neutral fat so obtained has the following characteristics.

Colour	..	..	Greyish white	Sapon. value	..	..	194.3
Sp. gr. at 30° ..		..	0.9139	Iodine value -	..	..	39.2
Butyro No. at 40°		..	51.5	R. M. value	..	..	0.12
Refractive index at 40°	..		1.4604	Hehner value	..	..	95.7
Acid value	..	..	0.28	Unsaponifiable matter	..		2.87%

Component Acids

For the estimation of the component fatty acids, 100 g. of the neutral fat were hydrolysed and the recovered fatty acids (95.7 g.) were then separated into " Solid " (53.56%) and " Liquid " (46.44%) acids by crystallising their lead salts from alcohol according to the modified Twitchell method (Hilditch et al., Biochem. J., 1929, 23, 327). Each group of the acids was then converted into the corresponding methyl esters which were fractionally distilled from a Willstätter bulb under vacuum (0.5—1.00 mm.). Saponification equivalents and iodine values of each of the fractions were determined. The individual fractions were further analysed for the identification of the acids present therein. The fractionation data are given in Tables I and II.

TABLE I

Methyl esters of solid acids " S " (whole fat)

S.E. = 299.2.   I.V. = 11.53.

Fraction No.	Wt.	B.p.	I.V.	S.E.
S_1	3.30 g.	140-160°	8.51	278.5
S_2	4.65	160-165°	8.70	286.4
S_3	4.44	165-170°	8.90	290.4
S_4	4.06	170-172°	9.42	292.5
S_5	4.82	172-173°	10.10	295.8
S_6	7.35	173-165°	10.20	299.7
S_7	7.50	165-155°	9.40	302.8
S_8	5.32	155-falling	8.7	305.6
S_9	4.95	Residue	19.4	..
Total	46.39			

TABLE II

Methyl esters of liquid acids " L " (whole fat)

S.E. = 294.3.   I.V. = 72.9

Fraction No.	Wt.	B.p.	I.V.	S.E.
L_1	3.00 g.	120-153°	68.6	285.2
L_2	3.42	153-155°	72.8	290.0
L_3	4.49	155-160°	76.9	292.8
L_4	5.00	160-162°	83.9	295.4
L_5	4.47	162-163°	84.9	296.1
L_6	3.98	163-falling	82.6	296.8
L_7	6.45	Residue	75.9	300.4
Total	30.81			

Qualitative Examination of Individual Fractions

S_1.—Acids obtained from this fraction melted at 55°. After recrystallisation of the acids from acetone, the melting point rose to 63°. On recrystallisation the melting point did not change. When mixed with pure palmitic acid, the melting point was lowered only to 62.8°. It is therefore concluded that no acid lower than palmitic is present.

S_2.—Acids from this fraction melted at 62°. After crystallisation of the acid from 94% alcohol the sample melted at 70.5°. Recrystallisation from the same solvent had no effect on the melting point. The sample when mixed with pure stearic acid melted at 70.1°. It is obvious that the fraction contains stearic acid.

S_8.—Acids from this fraction melted at 71°. After crystallisation from 94% alcohol the melting point rose to 75°. Further crystallisation had no effect on the melting point. The mixed melting point could not be taken, as a pure sample of arachidic acid was not available. The mean molecular weight was found to be 312.2, indicating the presence of arachidic and or other higher acids.

S_r.—The unsaponifiable matter from the soap solution of the residual fraction was removed by ether. The fatty acids liberated had S.E. 295.5 and I.V. 12.40 and melting point 55°. After crystallising from alcohol the melting point was 61°. On further crystallisation the melting point rose to 68°, which did not change on further crystallisation. (It may be a mixture of oleic, stearic and arachidic acids).

Fractions L_4, L_5 and L_6 were combined and acids recovered. 3.5 G. of the recovered acids were dissolved in about 40 c.c. of anhydrous ether. The solution was kept in a freezing mixture and bromine slowly added till distinctly red. After keeping the mixture for four hours at —5° to —10°, no precipitate was observed to occur. Then the excess of bromine in the solution was removed by washing with sodium bisulphite. Bromo-adducts soluble in ether were recovered and dissolved in light petroleum (b.p. 40-60°) and crystallised at 0°. No precipitate was formed, indicating thereby the absence of linoleic and linolenic acids, since these form insoluble bromo-additive products. The only unsaturated acid present, therefore, is oleic acid.

With the help of the above data, the component fatty acids of the mango fat have been calculated as given in Table III.

TABLE III

Component fatty acids of mango seed fat

Acids.	Solids (53.56%)	Liquids (46.44%)	Total (100)	Fatty acids (Wt. %)	Ex. N-8 (Mol. %)
Myristic	..	0.69	0.69	0.69	0.85
Palmitic	6.86	1.94	8.80	8.83	9.71
Stearic	33.87	..	33.87	33.96	33.66
As. arachidic	6.72	..	6.72	6.74	6.08
Oleic	5.99	43.67	49.66	49.78	49.70
Unsaponifiable	0.12	0.14	0.26	..	..

Glyceride Structure

For the estimation of glyceride structure, the neutralised fat was first separated by systematic crystallisation from acetone into three fractions, (A) least soluble, (B) medium soluble and (C) most soluble. Each fraction was then analysed for the component fatty acids by the ester-fractionation method, in the same way as the analysis of the whole fat was done. Fully saturated glycerides of the whole fat were also determined by the acetone permanganate oxidation method.

The characteristics of these three fractions from acetone and their fatty acid composition are given in Table IV.

<div align="center">TABLE IV</div>

Fractions obtained by crystallisation of mango seed fat from acetone

	A.		B.		C.	
Wt. (g.)	119.8		77.4		43.5	
Iodine value	35.2		41.4		48.4	
Saponification equivalents	288.4		286.9		285.6	
% Weight	49.8		32.1		18.1	
% Mol.	49.6		32.2		18.2	
Component fatty acids.	% Wt.	% Mol.	% Wt.	% Mol.	% Wt.	% Mol.
Myristic	0.39	0.48	0.56	0.67	1.45	1.77
Palmitic	6.50	7.19	12.36	13.52	9.80	10.68
Stearic	36.86	39.79	34.30	33.81	18.64	18.31
As. arachidic	10.43	9.49	4.05	3.63	1.35	1.21
Oleic	42.83	43.05	48.73	48.37	68.76	68.03

Fully Saturated Glycerides of the Whole fat

30.15 G. of the fat were dissolved in dry acetone (300 c.c.) and on oxidation with powdered potassium permanganate (120 g.) gave 4.6 g. of fully saturated glycerides of S.E. 294.3, A.V. 0.95, and I.V. 0.93. After correcting for acidic matter and residual unsaturated glycerides, it was estimated that the true fully saturated glyceride amounted to 14.57% by weight or 14.2% by mols. The corresponding S.E. of the true fully saturated glycerides would be 293.3, which indicates that they are mostly composed of palmito-stearins. In view of the predominence of stearic acid in the fat and palmitic acid forming a minor component, these fully saturated glycerides can be assumed to be composed of mono-palmito-distearin and tristearin.

From the above data the increments of the component acids in each fraction will be as given in Table V. The different possible groupings of glycerides calculated from the component acids are also included in the table. For these calculations small amounts of myristic acid is included in palmitic acid, while arachidic acid is included in stearic acid.

TABLE V

Composition of fractions A, B and C (Mol. %)

	A.	B.	C.	Total.	Whole fat as determined
Molar proportions of glycerides (%)	49.6	32.2	18.2	100	..
(a) Component fatty acids present (%) :					
Myristic	0.2	0.2	0.3	0.7	0.8
Palmitic	3.6	4.4	2.0	10.0	9.7
Stearic	19.7	10.9	3.3	33.9	33.7
As. arachidic	4.7	1.1	0.2	6.0	6.1
Oleic	21.4	15.6	12.4	49.4	49.7
(b) Component glycerides :					
Fully saturated glycerides	14.2	..	..	14.2	..
Mono-oleo di-saturated	6.6	17.6	..	24.2	..
Di-oleo mono-saturated	28.8	14.6	17.4	60 8	..
Tri-unsaturated	..	..	0.8	0.8	..

With due consideration of the solubility of the different glycerides, the approximate composition of the glycerides present in the various fractions can be estimated. Since the fully saturated glycerides are composed of palmito-stearins, they will be present in fraction A. The di-saturated-mono-unsaturated glycerides being less soluble can be taken as absent in the most soluble fraction C. While di-oleo glycerides being predominating, will be distributed in all the fractions. Tri-olein, if at all present, would be in

TABLE VI

Component glycerides of mango fat

	Fractions			
	A (49.6%)	B (32.2%)	C (18.2%)	Whole fat (100)
Fully saturated glycerides (14.2%)				
Palmito-di-stearin	8.7	..	..	8.7
Tri-stearin	5.5	..	..	5.5
Mono-oleo glycerides (24.2%)				
Palmito-stearo-olein	2.7	13.8	..	16.5
Di-stearo-olein	3.9	3.8	..	7.7
Di-oleo glycerides (60.8%)				
Palmito-di-olein	..	..	6.9	6.9
Stearo-di-olein	28.8	14.6	10.5	53.9
Tri-unsaturated (0.8%) Tri-olein	..	..	0.8	0.8

fraction C only. The palmitic acid in fractions A and B after accounting for the fully saturated glycerides may be regarded as palmito-stearo-olein. The arachidic acid in fraction A may be arachido-stearo-olein or arachido-di-olein. In fractions B and C, however, it would be present as arachido-di-olein only. Di-saturated glycerides being considered absent in fraction C, there would be small proportion of tri-olein present, after allocating oleic acid for di-oleo glycerides.

The approximate proportions of the various glycerides so estimated will therefore be as given in Table VI.

It will be observed from the above analysis that the glycerides of mango fat do not strictly conform to the " rule of even distribution " in as much as that the fully saturated glycerides content is about 14% although the saturated fatty acids form only about 50% of the mixed acids. Usually, the proportion of the fully saturated glycerides would be insignificant until the saturated acids form 60% of the total mixed acids.

In fatty acid composition mango fat resembles *Vateria Indica* fat (palmitic 10.2, stearic 35.8, arachidic 3.1 and oleic 47.8%. *cf.* Hilditch and Jones, *J. Soc. Chem. Ind.*, 1931, **51**, 468T) to a great extent. Being a solid fat, fairly rich in stearic acid, mango fat would have been very suitable for soap making. But its fat content is so very poor that it is doubtful whether it could be commercially exploited.

STUDIES IN THE NEGATIVELY CHARGED COLLOIDAL SOLUTIONS OF VARIOUS FERRIC SALTS. PART III. NEGATIVELY CHARGED MIXED SOL OF FERRIC OXIDE AND FERRIC MOLYBDATE

BY SUKHDEO PRASAD MUSHRAN AND SATYA PRAKASH

Negatively charged ferric molybdate sols have been prepared by peptising freshly precipitated ferric molybdate by caustic soda in presence of glucose and glycerine. The sols peptised by glucose and glycerine have respectively the compositions $21Fe_2O_3.Fe_2(MoO_4)_3.H_2O$ and $28Fe_2O_3.Fe_2(MoO_4)_3.$ $30H_2O$. Various characteristics of the sols have been investigated.

Graham (*Annalen*, 1865, **135**, 65) long ago recognised the existence of a sol of molybdic acid which he prepared by dialysis of a solution of sodium molybdate acidified with a slight excess of hydrochloric acid. The semi-colloidal nature of molybdic acid was studied by Bruni and Pappada (*Gazzetta*, 1901, **31**, 1, 244), Wöhler and Engels (*Koll.-Chem. Beih.*, 1910, **1**, 466), and Linder and Picton (*J. Chem. Soc.*, 1892, **61**, 155). Dhar and collaborators (*Kolloid Z.*, 1927, **42**, 124 ; *Z. anorg. Chem.*, 1930, **190**, 421) studied the viscosity of colloidal solutions of molybdic acid under different conditions. The colloidal nature of heavy metal molybdates has not been much studied. Weiser (*J. Phys. Chem.*, 1916, **20**, 640) obtained colloidal lead molybdate by precipitating the salt and washing with hot water. Dhar and Ghosh (*Z. anorg. Chem.*, 1926, **152**, 405) found that lead molybdate was peptised by ammonium molybdate. Prakash and Dhar (*J. Indian Chem. Soc.*, 1929, **6**, 587 ; 1930, **7**, 367) obtained the hydrogels of zirconium, thorium and stannic molybdate and Varma and Prakash (*Z. anorg. Chem.*, 1932, **205**, 241) investigated the peptisation of ferric molybdate by ferric chloride in presence of various peptising agents such as glucose, glycerine and urea. The sols and gels studied so far were positively charged and no work appears to have been done on the negatively charged sol or gel of ferric molybdate.

In previous communications of this series (Mushran and Prakash, *J. Indian Chem. Soc.*, 1946, **23**, 111, 391), the preparation, composition and various other characteristics of negatively charged colloidal solutions of ferric vanadate and borate were described. In this paper, the detailed study of the properties and composition of negatively charged ferric molybdate sols has been described.

When potassium molybdate is added to a ferric chloride solution, a yellowish white precipitate of ferric molybdate is obtained. We have observed that this precipitate of ferric molybdate can be dispersed by suitable concentrations of a caustic soda solution in presence of glucose or glycerine to give a bright red sol of ferric molybdate which can be shown by electrophoresis to be negatively charged. An idea of the peptisation can be had from the following figures :

Ferric chloride solution (1.5-2.5 c.c. containing 30.36 g. of Fe_2O_3 per litre) when mixed with 1.0 to 2.0 c.c. of a 10% potassium molybdate solution in presence of 0.4 to 3.0 c.c. of 20% glucose solution requires 2.0 to 4.2 c.c. of N-NaOH solution (total volume 10 c.c.) to bring about the complete peptisation in half an hour.

The same ferric chloride solution (1.0-2.5 c.c.) when mixed with 1.0 to 2.0 c.c. of 10% potassium molybdate solution in presence of 0.2 to 3.0 c.c. of glycerine requires 1.4 to 3.4 c.c. of N-NaOH solution (total volume 10 c.c.) to bring about the complete peptisation in half an hour.

EXPERIMENTAL

Sol A was prepared by mixing 50 c.c. of a ferric chloride solution (containing 30.36 g. of Fe_2O_3 per litre), 50 c.c. of 10% potassium molybdate solution, 25 c.c. of 20% glucose solution and 100 c.c. of N-NaOH solution. The total volume was raised to 250 c.c. The sol was dialysed for five days.

Sol B was prepared by mixing 100 c.c. of the same ferric chloride solution, 100 c.c. of 10% potassium molybdate solution, 100 c.c. of glycerine and 170 c.c. of N-NaOH solution. The total volume was raised to 500 c.c. The sol was dialysed for three days.

Compositions of the Sols

The amount of iron in a known volume of the sol was estimated by the use of the reagent cupferron (vide Part II of this series). The molybdate was estimated as MoO_3. For this, a known volume of the sol was dissolved in Merck's hydrochloric acid in a small pressure bottle and the solution was saturated in the cold with hydrogen sulphide. The bottle was then closed, heated on a water-bath until the precipitate completely settled. The precipitate was filtered off when it became cold, and was washed with dilute acid solution and finally with alcohol until the acid was completely removed. The moist filter paper with the solid was placed in a silica crucible and dried on a water-bath. The crucible was covered and heated very carefully over a small flame. The cover was then removed, the carbon was burnt off from the sides of the crucible at as low a temperature as possible, and by raising the temperature gradually, the sulphide was changed to the oxide and weighed. This gave the value of the total molybdate. In order to find out how much of the molybdate was in the combined state with iron, a known volume of the sol was co-agulated by potassium chloride, the total coagulum was collected, washed and estimated as MoO_3. The coagula have also been obtained cataphoretically and the concordance of the results shows that the equilibrium between the free and the combined molybdate is not appreciably altered. The combined iron corresponding to this amount of molybdate is calculated on the assumption that the ferric molybdate is $Fe_2(MoO_4)_3$. The rest of the iron is present as hydrated ferric oxide. From the ratio of the free to the combined iron, the empirical formula of the sol is calculated. The viscosity of the sol was measured by Ostwald's method at 30° and the amount of bound water was calculated from Hatscheck's equation (vide Part I of this series).

The sols were coagulated by KCl, centrifuged and the p_H values of the supernatant aqueous layers were determined using the hydrogen electrode. The p_H values obtained were 7.39 for sol A and 7.64 for sol B.

Conductivity Measurements

In the following tables are recorded the conductivities of these sols at various dilutions, at various temperatures and at different stages of ageing.

TABLE I

Per litre.	Sol A Glucose sol	Sol B Glycerine sol	Per litre.	Sol A Glucose sol	Sol B Glycerine sol
Total iron	3.0070 g.	2.9976 g.	Combined iron	0.1370	0.1034
Total molybdate (MoO_3)	0.8400	0.9050	Free iron	2.8700 g.	2.8942 g.
Combined molybdate (MoO_3)	0.5300	0.4000	Viscosity of sol (30°)	0 00828	0.00872 *
			Viscosity of water (30°)	0.00803	0.00803
Free molybdate (MoO_3)	0.3100	0.5050	Water, bound	0.02752	0.49530
Empirical formula	$21Fe_2O_3.Fe_2(MoO_4)_3. H_2O.$	$28Fe_2O_3.Fe_2(MoO_4)_3.30H_2O$			

* The high viscosities are due to the presence of a sufficient concentration of free glycerine, as the sol could not be dialysed for long. The instability of the sol also contributed towards this end.

TABLE IIA

Sp. conductivity at different dilutions (30°)

Dilutions.	Sp. conductivity $\times 10^4$ mho.		Dilutions.	Sp. conductivity $\times 10^4$ mho.	
	Sol A	Sol B		Sol A	Sol B
Original sol (X)	15.50	27.19	$X/2$	7.98	14.50
$5X/6$	12.71	23.12	$X/3$	5.54	10.10
$2X/3$	10.28	18.54	$X/6$	2.72	5.57

TABLE IIB

Sp. Conductivity on ageing (30°)

Date.	Sp. conductivity $\times 10^4$ mho.		Date.	Sp. conductivity $\times 10^4$ mho.	
	Sol A	Sol B		Sol A	Sol B
9.2.45	15.50	27.19	23.2.45	..	The sol settles
12.2.45	..	27.40	4.3.45	15.69	down
15.2.45	15.58	27.62	4.4.45	15.78	
18.2.45	..	27.66	4.5.45	15.91	

TABLE IIc

Sp. conductivity at different temperatures

Temp.	Sol A Sp. condy. $\times 10^4$ mho.	Diff. per 5°.	Sol B Sp. condy. $\times 10^4$ mho.	Diff. per 5°.
40°	18.50		32.50	
		1.49		2.66
35°	17.01		29.84	
		1.51		2.65
30°	15.50		27.19	
		1.37		2.63
25°	14.13		24.56	
		1.53		2.67
20°	12.60		21.89	
		1.39		2.89
15°	11.21		19.00	
Temp. of zero conductance (extrapolated)	—16.0°		—20.0°	
Temperature coefficient per 1°	0.29		0.54	

From the results recorded in the tables above it will be seen that in the case of sol A, the conductivities are proportional to the dilutions in the beginning and as the sol is further diluted, the conductivities do not decrease in the same proportion as the dilutions, suggesting hydrolysis of the sol at higher dilutions; in the case of sol B, the conductivities are not proportional to the dilutions at any dilution of the sol, suggesting marked hydrolysis of the sol on dilution. The conductivities of the sols increase on ageing. The sp. conductivity-temperature graphs are straight lines. The temperatures of zero conductance of the sols lie between —16.0° and —20.0°.

Extinction Coefficients of the Sols

Extinction coefficients were determined using Nutting's spectrophotometer at different dilutions and at different wave-lengths (X stands for the original undiluted sol).

TABLE III

Sol A

Wave-length.	X	X/2	Dilutions X/4	X/8	X/16
5000Å	..	..	2.35	1.19	0.60
5200	..	3.30	1.66	0.84	0.43
5400	..	2.31	1.16	0.59	0.30
5600	3.17	1.59	0.79	0.40	0.21
5800	2.20	1.10	0.56	0.28	0.16
6000	1.67	0.84	0.42	0.21	0.11
6200	1.12	0.56	0.28	0.15	0.08
6400	0.98	0.49	0.25	0.13	0.07

Sol B

Wave-length	X	X/2	X/4	X/8	Wave-length	X	X/2	X/4	X/8
4800Å	..	2.83	2.04	1.24	5800Å	1.05	0.65	0.41	0.30
5000	3.73	2.14	1.41	0.82	6000	0.72	0.45	0.30	0.27
5200	3.00	1.75	0.92	0.54	6200	0.53	0.38	0.28	0.23
5400	2.25	1.32	0.76	0.46	6400	0.40	0.30	0.24	0.18
5600	1.55	0.95	0.55	0.37					

It will be seen from the above table that in the case of sol A Beer's law is followed for dilutions X/2 and X/4 but for dilutions X/8 and X/16 there are slight discrepancies. In the case of sol B Beer's law is not followed for any dilution of the sol; the extinction coefficients are always greater than those computed on the basis of dilution. The hydrolysis of ferric molybdate at different dilutions has caused these deviations. Our results on the conductivities at different dilutions (Talbe II) also show similar behaviour.

Coagulation of the Sols

In the following table are recorded the minimum amounts of electrolytes necessary to coagulate 1 c.c. of the sols in a total volume of 10 c.c., the time allowed in each case being 30 minutes.

TABLE IV

Electrolytes.	Amount for coagulation		Electrolytes.	Amount for coagulation	
	Sol A.	Sol B.		Sol A.	Sol B.
$N/2$-NaCl	4.7 c.c.	0.7 c.c.	$N/250$-Ba(NO$_3$)$_2$	4.8 c.c.	0.9 c.c.
$N/2$-KCl	4.5	0.5	$N/250$-Sr(NO$_3$)$_2$	5.0	1.2
$N/2$-KNO$_3$	4.5	0.5	$N/250$-AlCl$_3$	2.9	0.5
$N/2$-KBr	4.5	0.5			

The coagulating powers of the ions thus fall in the following series :

$$NaCl < KCl, KBr, KNO_3 < Sr(NO_3)_2 < Ba(NO_3)_2 < AlCl_3$$

The effect of dilution on the coagulation values has also been investigated. Total volume was 10 c.c.

TABLE V

Electrolytes.	Amount necessary for coagulation of					
	1 c.c.	2 c.c.	3 c.c.	1 c.c.	2 c.c.	3 c.c.
	Sol A			Sol B		
$N/2$-NaCl	4.70	4.85	4.99	0.70	0.90	1.10
$N/2$-KCl	4.50	4.60	4.70	0.50	0.60	0.70
$N/2$-KNO$_3$	4.50	4.60	4.70	0.50	0.60	0.70

From Tables IV and V it is evident that the sols obey the Schulze-Hardy rule for coagulation with electrolytes, and that they show the normal behaviour with dilution.

Positively Charged Ferric Molybdate Sol

It was reported by Varma and Prakash (loc cit.) that the precipitate obtained by adding potassium molybdate to ferric chloride was only slightly peptised by ferric chloride alone to give a positively charged sol of ferric molybdate, but in presence of glucose, the peptisation occurred to a remarkable extent   In Table VI are shown our results on the composition of positively charged ferric molybdate sol.

The sol under investigation was prepared by mixing 40 c.c. of a ferric chloride solution (corresponding to 69.84 g. of Fe$_2$O$_3$ per litre), 25 c c. of 20% glucose solution and 15 c.c. of 10% potassium molybdate solution. The mixture was vigorously shaken, filtered, and the filtrate was kept in a parchment bag and then allowed to dialyse. It was observed that the sol could not stand much dialysis, as in the course of twelve hours it became opalescent and very viscous and finally settled down. The sol was therefore dialysed for six hours and was then transferred to a Jena bottle. Estimations for iron and molybdate were made exactly in the same way as in the case of the negatively charged ferric molybdate sol.

TABLE VI

Per litre.			Per litre.		
Total iron	..	16.4638 g.	Viscosity of sol (30°)	..	0.00876 g.
Combined molybdate (MoO$_3$)		9.7000	Viscosity of water (30°)	..	0.00803
Combined iron	..	2.5080	Water, bound	..	0.5786
Free iron	..	13.9558	Empirical formula	.	11Fe$_2$O$_3$.2Fe$_2$(MoO$_4$)$_3$. 3H$_2$O

Sol contained 15.8620g. of chloride ions per litre.

DISCUSSION

According to Scheele a solution of ferric chloride gives a brown precipitate when treated with potassium molybdate. The analysis of this precipitate given by Marckwald ("Uber die Molybdate des Kobalts, Nickels, Mangans, Eisens, Chroms, und Aluminiums," Berlin, 1895) corresponds to $Fe_2(MoO_4)_3$. The precipitate appears according to the following equation :

$$2FeCl_3 + 3K_2MoO_4 = Fe_2(MoO_4)_3 + 6KCl.$$

We have observed that the precipitated ferric molybdate, though not easily peptised by caustic soda alone, goes to form a clear red sol if peptised in presence of glucose or glycerine. During the course of peptisation in presence of caustic soda, a part of the ferric molybdate may undergo hydrolysis according to the following reaction :

$$xFe_2(MoO_4)_3 + 6yNaOH \longleftrightarrow (x\text{-}y)Fe_2(MoO_4)_3.yFe_2O_3. + 3yNa_2MoO_4 + 3yH_2O.$$
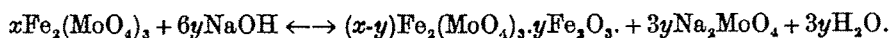
A further hydrolysis of ferric oxide-ferric molybdate complex may occur during dialysis also yielding a higher content of ferric oxide :

$$xFe_2(MoO_4)_3 \longleftrightarrow x'Fe_2(MoO_4)_3 y'Fe_2O_3 \longleftrightarrow y''Fe_2O_3.$$

The composition of the sols analysed are given below :

Negatively charged : $21Fe_2O_3.Fe_2(MoO_4)_3.H_2O$ (glucose sol).

$28Fe_2O_3.Fe_2(MoO_4)_3.30H_2O$ (glycerine sol).

Positively charged : $11Fe_2O_3.2Fe_2(MoO_4)_3.3H_2O$.

From the compositions given here it is clear that the positively charged sol contains a higher proportion of ferric molybdate than the negatively charged sols. The negatively charged sols are prepared mainly in the alkaline medium. Even after dialysis of the sols, the p_H of the supernatant aqueous layers, obtained after the coagulation of the sols with electrolytes, lie between 7.39 and 7.64. The sols prepared are sufficiently alkaline. This accounts for the larger proportion of ferric oxide in the negatively charged sols.

It will be interesting to discuss the temperature coefficients of conductivity of the negatively charged ferric molybdate sols. The temperature coefficients per 1° and the conductances at 35° are given below.

	Condy. at 35°	Temp. coeff.
Glucose sol (A)	17.01×10^{-4} mhos	0.29
Glycerine sol (B)	29.84	0.54

The temperature coefficient of sol A is thus 1.7% of the conductance at 35° and of sol B is 1.8% of the conductance at 35°. The temperature coefficients per 1° are therefore always less than 2% of the conductances at 35°.

CONCLUSION

Various characteristics of negatively charged ferric molybadte sols have been studied and from the results recorded in the foregoing tables the following observations may be summarised :

(*i*) The electrical conductivity of the 'glucose sol' is proportional to dilution in the beginning and as the sol is further diluted, the conductivities do not decrease in the same proportion as the dilution, suggesting hydrolysis of the sol at higher dilutions.

(*ii*) The electrical conductivity of the 'glycerine sol' is not proportional to dilution for any dilution of the sol, suggesting marked hydrolysis of the sol on dilution.

(*iii*) The electrical conductivities of the sols are linear functions of temperatures. The temperatures of zero conductance lie between -16.0° and -20.0°.

(*iv*) The temperature coefficients of conductivity per 1° of the sols are always less than 2% of the conductances at 35°.

(*v*) The conductivities of the sols increase on ageing.

(*vi*) The extinction coefficients of the glucose sol are proportional to dilution in the beginning and as the sol is further diluted, the extinction coefficients do not decrease proportionately with dilution.

(*vii*) The extinction coefficients of the glycerine sol do not decrease in the same proportion as dilution. The product of extinction coefficient and dilution is not constant. It shows a gradual increase as the dilution progresses.

(*viii*) The sols obey the Schulze-Hardy rule for coagulation with electrolytes. They show the normal behaviour on dilution.

(*ix*) The p_H values of the dispersion medium lie between 7.39 and 7.64 showing that the sols are slightly basic owing to the stabilising hydroxide ions.

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ON ORGANO-ARSENICAL COMPOUNDS. PART I.

By D. N. Chatterjee and T. N. Ghosh

For enhanced therapeutic activity against trypanosomes, p-amidinoacetylaminophenylarsonic acid has now been synthesised.

It is known that trypanosomes which have become resistant to one group of arsenical compounds may yet remain sensitive to another. Ehrilch ($Z.$ $angew.$ $Chem.$, 1910, **23**, 2) showed many years ago that a number of arsenobenzene derivatives, of which arseno-phenylglycine is a type, is capable of curing arsenic-resistant infections. These derivatives are all characterised by the presence in their make-up of the acetic acid radical, $-(CH_2.CO_2H)$. In this connection it should be mentioned that the simple compound, arseno-acetic acid, has very little action on parasites.
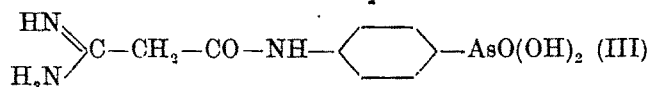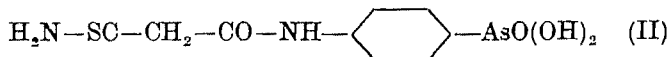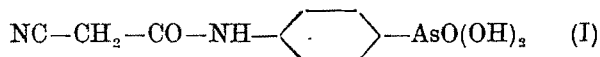
Amongst the derivatives of p-aminophenylarsonic acid, so far prepared and tested, tryparsamide has been found very effective against trypanosomes. It is, however, interesting to observe that though the phenylglycine analogue of phenylarsonic acid is of comparatively slight value as a trypanocide, the corresponding amide or rather its sodium salt (tryparsamide) is highly effective in certain forms of trypanosomiasis ($Tr.$ $gambiense$, African sleeping sickness and mal de $caderas$) ($cf.$ Pearce and Brown, $J.$ $Exp.$ $Med.$, 1921, **34**, 1). The question naturally arises as to whether the groupings, CH₂-COOH in the case of arsenobenzene compounds and CH₂-CONH- in the case of phenylarsonic acid compounds, have any special significance in connection with the activity of trypanocidal substances. Further research is, however, needed before any definite relationship can be established.

King, Lourie and Yorke ($Lancet$, 1937, **233**, 136) have found that some symmetrical diamidinoalkanes exhibit pronounced trypanocidal action. In recent years a large number of aromatic diamidines has been synthesised by Ashley, Barber, Ewins, Newbery and Self ($J.$ $Chem.$ $Soc.$, 1942, 103), some of which have been found to possess pronounced trypanocidal activity and are found to cure early cases of sleeping sickness in a fortnight or less and act on the naturally arsenic-resistant $T.$ $rhodesiense$ in human being. These observations have opened up a new line of research along which important therapeutic substances may be discovered.

In search for a drug which may prove lethal to "arsenic-fast" trypanosomes and also effective in late cases, it has been considered desirable to prepare compounds which will embrace the above features—namely, derivatives of p-aminophenylarsonic acid containing the groupings, CH₂-CONH- and an amidino group. With this idea in view, p-arsanilic acid has now been condensed with ethyl cyanoacetate at 165-70° to yield the compound (I). This cyano derivative reacts with hydrogen sulphde at 0° to give the thioamide (II). It was expected that hydrogen sulphide might also reduce the arsonic acid group to arsenious sulphide (compare German Patent, 205617), but as the compound isolated is soluble in aqueous alkali and ammonia and as its analyses conform

to the structure (II), the possibility of any reduction having taken place is precluded. Moreover, in keeping with the structure (II), the compound is desulphurised by yellow oxide of mercury (cf. Guha, J. Amer. Chem. Soc., 1922, **44**, 1502).

The compound (I) has now yielded the desired amidine derivative (III) via the corresponding imino-ether hydrochloride. The compound (III), which is a derivative of p-aminophenylarsonic acid, contains both the amidino and CH$_2$-CONH- groupings.

$$NC-CH_2-CO-NH-\langle\rangle-AsO(OH)_2 \quad (I)$$

$$H_2N-SC-CH_2-CO-NH-\langle\rangle-AsO(OH)_2 \quad (II)$$

$$\begin{matrix} HN \\ \\ H_2N \end{matrix}\Big\rangle C-CH_2-CO-NH-\langle\rangle-AsO(OH)_2 \quad (III)$$

EXPERIMENTAL

Condensation of Ethyl Cyanoacetate with p-Arsanilic Acid

Formation of p-*Cyanoacetylaminophenylarsonic Acid* (I).—Well powdered para-arsanilic acid (50 g.) and ethyl cyanoacetate (50 g.) were thoroughly mixed together and heated under reflux in an oil-bath at 165-70° for 8 hours. The mixture became viscous after 2 hours' heating and then gradually turned into a dark grey mobile liquid. Some amount of ammonia was evolved due to decomposition of excess of ethyl cyanoacetate.

Next day the thick pasty mass was triturated with 10% sodium hydroxide solution, filtered and the filtrate acidified, under cooling, with excess of concentrated hydrochloric acid, when a brown gelatinous precipitate was obtained. The solid was filtered, thoroughly washed with dilute hydrochloric acid and then with water. It is insoluble in hot water and in ordinary organic solvents. It was purified by dissolving in aqueous sodium bicarbonate and treating with charcoal. After standing for about 1 hour, the solution was filtered and acidified with dilute hydrochloric acid. The brown gelatinous mass was filtered, washed thoroughly with water and dried in a vacuum desiccator, when it turned granular and assumed a slightly deeper tinge, yield 12 g. It does not melt even at 300°. (Found : N, 9.42 ; As, 25.81. C$_9$H$_9$O$_4$N$_2$As requires N, 9.86 ; As, 26.38 per cent).

The above condensation does not at all take place below 150° and takes place to a very small extent between 150° and 160°, the maximum yield of the condensation product having been obtained by heating the ingredients at 165-70°.

p-*Thioamidoacetylaminophenylarsonic Acid* (II).—The above compound (I, 8 g.) was dissolved in just the requisite quantity of aqueous sodium bicarbonate and the solution after being cooled to 0° was saturated with sulphuretted hydrogen gas. The solution was then kept in the refrigerator overnight in a well-stoppered flask.

Next day the solution was filtered and acidified, under cooling, with dilute hydrochloric acid, when a brown solid was precipitated. It was dried and washed thoroughly with carbon disulphide. It is insoluble in hot water and in ordinary organic solvents. It was purified by solution in aqueous ammonia and by precipitation with dilute hydrochloric acid, yield 5 g. It does not melt even at 300°. (Found : N, 9.28 ; S, 10.48 ; As, 22.92. C$_9$H$_{11}$O$_4$N$_2$SAs requires N, 8.80 ; S, 10.06 ; As, 23.56 per cent).

The aqueous solution of the sodium salt is easily desulphurised by yellow oxide of mercury and gives immediately an insoluble precipitate with mercuric chloride. The aqueous solution of the sodium derivative of the compound (I), however, does not give any precipitate with mercuric chloride.

p-*Amidinoacetylaminophenylarsonic Acid* (III).—A suspension of a finely powdered sample of the above compound (I, 6 g.) in dry ether (20 c.c.) was treated with absolute alcohol (3.5 c.c.), and the mixture was saturated with dry hydrochloric acid gas at 0°. The mixture was then kept in the refrigerator in a well-stoppered flask for 6 days with occasional, mild shaking. The solid (the corresponding imino-ether hydrochloride) was filtered, washed with dry ether and dried in a vacuum desiccator. The filtrate, when kept in the refrigerator for 6 days more, deposited a further quantity of the imino-ether hydrochloride, the total yield amounting to 5.5 g.

The dry imino-ether hydrochloride (5.5 g.) was finely powdered and treated with alcoholic ammonia (15%, 5c.c.) and kept in a well-stoppered flask in the refrigerator for 5 days with occasional, mild shaking. The solid (the corresponding amidine hydrochloride) was filtered and dried in a vacuum desiccator. It was then triturated with very dilute hydrochloric acid and the solution, after filtration to remove slight impurity, was carefully treated, under cooling, with dilute ammonium hydroxide, when a pale green voluminous precipitate of the free amidine began to separate. The addition of dilute ammonium hydroxide was continued till maximum precipitation was obtained and the solution just turned green. The solid (3 g.) was purified by solution in dilute hydrochloric acid and precipitation, as above, by dilute ammonium hydroxide. The amidine base (III), thus obtained, is a light green powder when dried and does not melt even at 300°. (Found : N, 13.52 ; As, 25.61. $C_9H_{12}O_4N_3As$ requires N, 13.95 ; As, 24.89 per cent). It is readily soluble in aqueous sodium bicarbonate and in dilute ammonium hydroxide and also readily soluble in dilute mineral acids. It is insoluble in hot water and in ordinary organic solvents except glacial acetic acid in which it is sparingly soluble. It could not be, however, crystallised from glacial acetic acid.

A SYNTHESIS OF 2-BENZOYL-4-ETHYLRESORCINOL

VIDYADHAR MANJULAL THAKOR AND NARSINH MULJIBHAI SHAH

A synthesis of 2-benzoyl-4-ethyl resorcinol has been described

It is well known that the Fries migration is widely employed for the preparation of phenolic ketones. In recent years, the migration has been extended to the esters of hydroxycoumarins. It gives rise to hydroxy-acyl-coumarins, which, on elimination of the pyrone ring, yield otherwise difficultly accessible 2-acyl-resorcinols. Several 2-acyl-resorcinols have thus been prepared by Limaye and his co-workers (*Ber.*, 1932, **65,** 375; 1934, **67,** 12; *Rasayanam*, 1937, 80; 1938, 141; 1939, 191 *et seq*).

In connection with other work, 2-benzoyl-4-ethylresorcinol was required for purposes of comparison; since it was not known, we have employed the above method and synthesised it from 4-ethylresorcinol (I), which under the customary conditions of the Pechmann reaction, yields 7-hydroxy-6-ethyl-4-methylcoumarin (II), the benzoyl ester (III) of which, on being subjected to the Fries migration gives 7-hydroxy-6-ethyl-8-benzoyl-4-methylcoumarin (IV). It is hydrolysed by alkali and on acidification, 2-benzoyl-4-ethylresorcinol (V) is obtained. It gives deep colouration with alcoholic ferric chloride solution and dissolves in alkali giving a yellow solution. Further, it easily undergoes the Pechmann condensation with ethyl acetoacetate yielding the original coumarin (IV), a reaction characteristic of 2-acyl-resorcinols.
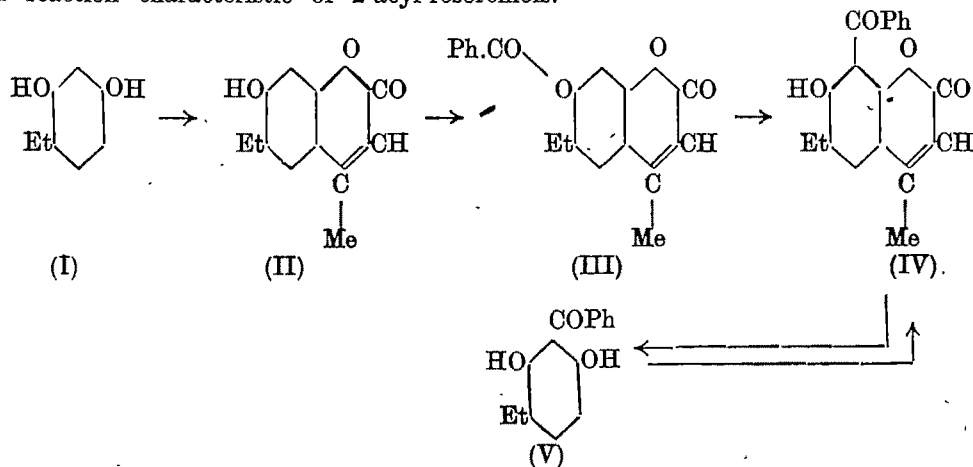
EXPERIMENTAL

7-Hydroxy-4-methyl-6-ethylcoumarin (II) required in this work was prepared by the Pechmann condensation of 4-ethylresorcinol with ethyl acetoacetate. Phosphorus oxychloride as the condensing agent was found to give the best yields, m.p. 217°. Shah and Samant (M.Sc thesis, Bom. Univ., 1935) give m.p. 211-12°; Limaye (*Rasayanam*, 1941, 201) gives m.p. 213°; Chakravarti and Chakravarti (*J. Indian Chem. Soc.*, 1939, **16**, 149) give m.p. 210°.

7-Benzoyloxy-4-methyl-6-ethylcoumarin (III) was prepared by benzoyl chloride-pyridine method, m.p. 155°.

Fries migration of (III) : *Formation of 7-Hydroxy-4-methyl-6-ethyl-8-benzoylcoumarin* (IV).—The benzoyloxy derivative (1 mol.) was intimately mixed with powdered anhydrous aluminium chloride (3.3 mols.) and heated in an oil-bath at 150-160° for nearly 2 hours. Hydrochloric acid fumes were evolved and the mixture melted and formed a yellow paste. It was cooled, ice and hydrochloric acid added ; the solid obtained collected, washed and crystallised from alcohol in yellow needles, m.p. 160-61°. It gives a deep violet colour with alcoholic ferric chloride and dissolves in alkali to a yellow non-fluorescent solution.

2-Benzoyl-4-ethylresorcinol (V).—The product (IV, 5 g.) was refluxed with alkali solution (20% ; 30 c.c.) for 2-2½ hours and cooled. It was then acidified and the separated solid collected, washed with water and crystallised from acetic acid as yellow needles, m.p. 125-26°, yield 2 g. (Found : C, 74.2 ; H, 5.9. $C_{15}H_{14}O_3$ requires C, 74.4 ; H, 5.8 per cent). It easily dissolves in methyl and ethyl alcohols, ether, acetone and acetic acid, and less so in benzene, chloroform and petrol ethers.

The *dimethyl ether*, prepared by dimethyl sulphate, crystallised from methanol as prisms, m.p. 60°. (Found : C, 75.4 ; H, 6.6 ; $C_{17}H_{18}O_3$ requires C, 75.6 ; H, 6.7 per cent).

The *acetyl* derivative melts at 65° ; the *benzoyl* derivative melts at 60°.

Pechmann condensation.—The resorcinol (V, 1 g.) was mixed with ethyl acetoacetate (1 g.) and concentrated sulphuric acid (5 c.c.) and the mixture kept for 24 hours. It was then poured into cold water and the solid obtained crystallised from acetic acid as yellow needles, m.p. 160° ; mixed m.p. with an authentic sample (IV) remained unchanged.

The authors express their thanks to Dr. R. C. Shah.

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BROMINATION OF COMPOUNDS CONTAINING TWO AROMATIC NUCLEI. PART III. BROMINATION OF ARYL ESTERS OF O-CRESOTIC ACID

By GANAPATRAO VISHRAMRAO JADHAV AND MAHOMAD ASLAM

Bromination of phenyl, o-, m- and p-cresyl, m- and p-nitrophenyl and β-naphthyl esters of o-cresotic acid is described. In the case of phenyl, o-, m- and p-cresyl esters mono- and dibromo derivatives are obtained. Their constitutions have been proved by hydrolysis and confirmed by synthesis.

The work is the extension of the work of Jadhav and Rangwala (*J. Indian Chem. Soc.*, 1935, **12**, 89 ; *Proc. Ind. Acad. Sci.*, 1935, **1**, 616). It has been observed that the presence of the free OH group in the molecule facilitates the reaction and directs the bromine atom in the nucleus containing it, in the position *para* to the OH group. The presence of the negative group like NO_2 in the phenolic part further facilitates the reaction and brominated products separate out sooner. Phenyl, o-, m-, p-cresyl, m-(p-nitro)-phenyl and β-naphthyl esters have been worked out.

No higher bromo derivatives could be obtained by carrying out bromination in a solvent, but liquid bromine could give dibromo derivatives only in the case of phenyl and m-cresyl esters, whereas the dibromo derivatives of o- and p-cresyl esters could be prepared only by using their monobromo derivatives and liquid bromine.

The presence of NO_2 group in the nitrophenyl esters so completely deactivates the molecule that even with liquid bromine only monobromo compounds are obtained. In the case of β-naphthyl ester, a mixture of bromo compounds is formed which can not be completely purified.

The constitution of these bromo compounds has been proved by their hydrolysis and confirmed by their synthesis except in the case of the dibromo derivative of p-cresyl ester which has not been prepared.

EXPERIMENTAL

For the preparation of the monobromo derivatives 16 c.c. of a 20% solution of bromine in acetic acid for 4 g. of the acid were used at room temperature when bromine was readily absorbed and the bromo derivative separated in a crystalline form after about $\frac{1}{2}$-1 hour, the ester being first dissolved in acetic acid. They are described in Table IA.

In the preparation of the dibromo derivatives of phenyl and m-cresyl esters, the ester and liquid bromine in the proportion of 1:2 by weight were used. Whilst in the case of o- and p-cresyl esters the monobromo compound and liquid bromine in the proportion of 2:1 and 1:1 respectively were used. In each case the reaction mixture was shaken for about half an hour and then diluted with water and treated with sodium bisulphite to remove the excess of bromine. They were crystallised from acetic acid. (*vide* Table IIA).

The hydrolysis of all the compounds described here was effected by boiling the substance under reflux with 5-8% sodium hydroxide solution for four to five hours and then passing carbon dioxide into the solution, when the phenolic portion separated. This

was removed by extraction with ether and the aqueous layer gave on acidification 5-bromo-o-cresotic acid. In the case of nitrophenols, β-naphthol and p-bromo-o-cresol and p-bromo-m-cresol, the phenols also were identified.

The synthesis of the bromo compounds has been carried out by using the quantities of the bromo-acid, required phenol and phosphorus oxychloride as shown in Tables IB and IIB and heating the reaction mixture at the temperatures shown, for about half an hour. The reaction mixture is then diluted with water and the solid washed with dilute alkali. It is finally crystallised from acetic acid and mixed melting point taken.

TABLE IA   TABLE IB

B.B. indicates bromobenzoate

Substance.	Formula.	M.p.	Found :	Calc.	Acid.	Phenol.	POCl$_3$.	Temp.
Phenyl 2-hydroxy-3-methyl-5-BB	C$_{14}$H$_{11}$O$_3$Br	81-82°	Br. 26.3%	Br. 26.06%	2 g.	1.5 g.	1 c.c.	120-25°
o-Cresyl 2-hydroxy-3-methyl-5-BB	C$_{15}$H$_{13}$O$_3$Br	147-48°	25.0	24.9	2	1.5	1	130-35°
m-Cresyl 2-hydroxy-3-methyl-5-BB	C$_{15}$H$_{13}$O$_3$Br	124-25°	24.7	24.9	2	1.5	1	120-25°
p-Cresyl 2-hydroxy-3-methyl-5-BB	C$_{15}$H$_{13}$O$_3$Br	123-24°	25.0	24.9	2	1.5	1	120-25°
m-Nitrophenyl 2-hydroxy-3-methyl-5-BB	C$_{14}$H$_{10}$O$_5$Br	133-34°	23.0	22.7	2	1.5	1	125-30°
p-Nitrophenyl 2-hydroxy-3-methyl-5-BB	C$_{14}$H$_{10}$O$_5$NBr	187-88° 165-	22.7 N, 3.9	22.7 N, 3.98	4	3.5	2.5	130-35°
β-Naphthyl 2-hydroxy-3-methyl-5-BB	C$_{18}$H$_{13}$O$_3$Br	66°	Br. 22.3	Br, 22.4	4	3	2.5	130-35

TABLE IIA   TABLE IIB

Substance.	Formula.	M.p.	Found :	Calc.	Acid.	Phenol.	POCl$_3$.	Temp.
4-Bromo phenyl 2-hydroxy-3-methyl-5-BB	C$_{14}$H$_{10}$O$_3$Br$_2$	147-48°	Br. 41.2	Br, 41.4	5 g.	4 g.	3 c.c.	130-35°
2-Methyl-4-bromo-phenyl 2-hydroxy-3-methyl-5-BB	C$_{15}$H$_{12}$O$_3$Br$_2$	150-51°	39.8	40.0	2	1.5	1	130-35°
3-Methyl-4-bromophenyl 2-hydroxy-3-methyl-5-BB	C$_{15}$H$_{12}$O$_3$Br$_2$	138-39°	40.1	40.0	4	3.5	2.5	125-30°
4-Methyl-2-bromo-phenyl-2-hydroxy-3-methyl-5-BB	C$_{15}$H$_{12}$O$_3$Br$_2$	92-93°	39.8	40.0				

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BROMINATION OF COMPOUNDS CONTAINING TWO AROMATIC NUCLEI. PART IV. BROMINATION OF ARYL ESTERS OF 2-NAPHTHOIC ACID

BY GANPATRAO VISHRAMRAO JADHAV AND MAHOMAD ASLAM

Bromination of phenyl, o-, m-, p-cresyl, o-, m-, p-nitrophenyl, α-, β- naphthyl, p-bromophenyl and 4-bromo-o-cresyl esters of 2-naphthoic acid is described. In the case of phenyl, o- and p-cresyl esters only 5-bromo-2-naphthoic acid could be isolated, whilst in the case of α-, β-naphthyl, and o-, m-cresyl esters, bromine enters the phenolic part of the molecule, and in the case of the rest it enters the acidic part. The constitution of the brominated esters has been proved by hydrolysis and confirmed by mixed melting point.

The present work was taken up with a view to studying the reactivity of naphthalene ring in the aryl esters of 2-naphthoic acid in bromination as compared with the benzene ring in the aryl esters of benzoic acid. It was observed by Jadhav and Rangwala (*J. Indian Chem. Soc*, 1935, **12**, 89) that bromination of simple aryl esters of benzoic acid could give better yields in presence of fuming nitric acid and that bromine entered the phenolic part, whilst in the case of nitrophenyl esters, bromination could be effected only in presence of fuming nitric acid and then too, bromine was found to enter the acidic part.

In the present work bromination of phenyl, o-, m-, p-cresyl, o-, m-, p-nitrophenyl, α-, β-naphthyl, p-bromophenyl and 4-bromo-o-cresyl esters of 2-naphthoic acid has been carried out in acetic acid medium. In the case of α- and β-naphthyl esters only, bromination takes place at room temperature and bromo derivatives with bromine in the phenolic part are obtained. Similar bromo derivative is obtained in the case of m-cresyl ester, but the reaction has to be carried out at boiling water-bath temperature.

In the case of phenyl, o- and p-cresyl 2-naphthoates, the bromination takes place at the boiling water-bath temperature, that too if the amount of acetic acid is just a little less than that required for complete dissolution of the ester. The brominated product is 5-bromo-2-naphthoic acid as confirmed by analysis and mixed melting point. It seems that bromination first takes place and the hydrobromic acid formed in the reaction hydrolyses the bromo-esters. To prove this, first the action of hydrobromic acid has been tried on the original esters under the same experimental conditions and they could be recovered unchanged. Afterwards the same esters of 5-bromo-2-naphthoic acid are treated with hydrobromic acid under the same experimental conditions, when hydrolysis is found to take place and 5-bromo-2-naphthoic acid is obtained.

In the case of o-, m- and p-nitrophenyl esters, the presence of nitro group in the phenolic part of the molecule deactivates it, but bromine could still enter the acidic part and give stable nitrophenyl esters of 5-bromo-2-naphthoic acid at the temperature of the boiling water-bath. Similarly in the case of p-bromophenyl 2-naphthoate and 4-bromo-o-cresyl 2-naphthoate, bromination at boiling water-bath temperature could give the corresponding esters of 5-bromo-2-naphthoic acid.

Bromination of m-cresyl 2-naphthoate with excess of bromine at the boiling water-bath temperature gives a dibromo derivative, 4-bromo-m-cresyl 5-bromo-2-naphthoate.

The constitutions of these bromination products has been proved by their hydrolysis except in the case of 4-bromophenyl and 4-bromo-*m*-cresyl 2-naphthoates and confirmed by mixed melting points with genuine samples prepared by the condensation of 5-bromo-2-naphthoic acid with the respective phenol.

EXPERIMENTAL

The ester was suspended in glacial acetic acid, liquid bromine was gradually added to it and the mixture was heated on a boiling water-bath for the required period. On cooling the reaction mixture, a solid separated which was crystallised from acetic acid. The compounds are described in Table I.

TABLE I

N indicates naphthoate.

Ester (4.g. each)	Br$_2$.	Acetic acid	Hours.	Name of product.	M.p.	Formula,	Bromine. Found.	Calc.
Phenyl 2-N	3 g.	35 c.c.	4	5-Bromo-2-naphthoic acid	263-64°	$C_{11}H_7O_2Br$	31.7	31.9
o-Cresyl 2-N	4	35	5	5-Bromo-2-naphthoic acid	263-64°	$C_{11}H_7O_2Br$	31.5	31.9
m-Cresyl 2-N	2.5	35	3	4-Bromo-*m*-cresyl 2-N	127-28°	$C_{18}H_{13}O_2Br$	23.4	23.5
p-Cresyl 2-N	3	35	6	5-Bromo-2-naphthoic acid	263-64°	$C_{11}H_7O_2NBr$	32.2	31.9
o-Nitrophenyl 2-N	6.5	50	3	*o*-Nitrophenyl 5-bromo-2-N	167-68°	$C_{17}H_{10}O_4NBr$	21.6	21.5
m-Nitrophenyl 2-N	3.5	50	3	*m*-Nitrophenyl 5-bromo-2-N	172-73°	$C_{17}H_{20}O_4NBr$	21.5	21.5
p-Nitrophenyl 2-N	3.5	50	3	*p*-Nitrophenyl 5-bromo-2-N	200-1°	$C_{17}H_{10}O_4Br$	21.8	21.5
1-Naphthyl 2-N	2.5	50	2*	4-Bromo-1-naphthyl 2-N	151-52°	$C_{21}H_{13}O_2Br$	21.4	21.2
2-Naphthyl 2-N	2.5	70	24*	1-Bromo-2-naphthyl 2-N	164-65°	$C_{21}H_{13}O_2Br$	21.1	21.1
m-Cresyl 2-N	7	40	5	4-bromo-*m*-cresyl 5-bromo-2-N	147-48°	$C_{18}H_{12}O_2Br_2$	37.7	38.1
4-Bromophenyl 2-N	2.5	40	3	4-Bromophenyl 5-bromo-2-N	143-44°	$C_{17}H_{10}O_2Br_2$	39.1	39.4
4-Bromo-*o*-cresyl 2-N	2.5	40	4	4-Bromo-*o*-cresyl 5-bromo-2-N	136-37°	$C_{18}H_{12}O_2Br_2$	37.6	38.1

* The reaction mixture was left at room temperature.

Hydrolysis.—The bromo-esters were boiled for 4-5 hours under reflux with 7-8% sodium hydroxide solution in presence of a little alcohol. Carbon dioxide was then passed through the solution, except in the case of *o*-nitrophenyl 5-bromo-2-naphthoate, in which case the phenol was separated by steam distillation, when the phenolic component separated was extracted with ether and the phenol was confirmed by mixed melting point. The solution left after the removal of phenol gave on acidification 5-bromo-2-naphthoic acid, confirmed by mixed point.

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INFLUENCE OF METALLIC SALTS ON THE SIZE-FREQUENCY OF GELATIN-PROTECTED EMULSIONS

By C. S. NARWANI AND T. C. PARAKH

The size-frequency of the gelatin-protected emulsions has been measured from the time-accumulation curves, obtained from the change in transparency of cream-zone of transparent emulsions with time, by means of a photo-electric cell. The size-frequency curves have been plotted for the transparent emulsions of amyl acetate in 1% gelatin-water-glycerine sol in presence of 1-5 millimoles of (i) KCl, (ii) KBr, (iii) KSCN, (iv) KI, (v) K_2SO_4. The changes in viscosities of the continuous phase and the interfacial tension between the continuous and the disperse phase with the addition of the above-mentioned salts have been studied experimentally and the influence of these changes compared with those in the size-frequency of particles of the emulsions. The amount of the disperse phase with varying radii as well as the size-frequency decrease in the order: $K_2SO_4 > KCl > KBr$, while it increases slightly on addition of KI and KSCN, the former being more effective than the latter; the change in interfacial tension follows the same order.

Clowes (*J. Phys. Chem.*, 1916, **20**, 407) observed that the addition of small amounts of NaCl up to 0.1M to the emulsions of olive oil in dilute soap solutions increased their stability due to the adsorption of Cl' ions in excess of Na· ions on the soap particles, while in the case of higher concentrations, the stabilising film was precipitated and the emulsion broke. Carpenter (*ibid.*, 1927, **31**, 1873) and Carpenter and Kucerol (*ibid.*, 1931, **35**, 2619) working on the influence of salts on the optical rotation of gelatin, found that salts produced lowering of optical activity, the magnitude of the effect decreasing in the order: KCl < KBr < KNO$_3$ < KClO$_3$ < KI < KSCN; this order compares well with that of Bancroft (*ibid.*, 1915, **19**, 349) for adsorption of anions by albumin. The adsorption of various neutral·salts on isoelectric gelatin has been studied by Docking and Heymann (*ibid.*, 1939, **43**, 513) and the order obtained for potassium salts is SO$_4$ < Cl < NO$_3$ < Br < I < CNS. The object of the present work is to ascertain if there is a change in the size of the particles as studied from size-frequency curves of transparent emulsions of amyl acetate in gelatin sols, treated with small quantities of KCl, KBr, KI, K_2SO_4 and KSCN. For obtaining the size-frequency curves according to the method of Kraemer and Stamm (*J. Amer. Chem. Soc.*, 1924, **46**, 2709), the time-accumulation curves have been plotted by measuring the change in transparency of cream-zone of transparent emulsion by a photo-electric cell. Further, it has been examined if the change in stability of such emulsions, determined from the stand-point of viscosity and interfacial tension, tallies with the change in size-frequency of the particles.

EXPERIMENTAL

A transparent gelatin-protected emulsion was obtained by dispersing amyl acetate in the mixture of 57 c.c. of gelatin-water sol and 43 c.c. of glycerine

·(dehydrated), the refractive indices of both the phases being equal at 35°. The emulsion (50%), prepared by gradual addition of the disperse phase and shaking in the mechanical shaker and homogenised under high pressure, was used in every experiment. The salt, whose influence was to be studied, was dissolved in the continuous phase before preparing the emulsion.

A definite volume of the emulsion was introduced into a well dried, rectangular, white glass bottle of plane parallel sides, having dimensions, $4'' \times 2.5''$ $\times 1''$ and an air-tight cork, and was placed in an air-thermostat at $35°\pm0.20$ on a stable stand with sliding arrangement, in horizontal as well as in vertical direction, opposite a fixed metallic slit $(1.5'' \times 0.5'')$ in the back wall of the thermostat. Just behind the slit was an electric lamp (12 volts, 75 watts) with a convex lens to give a parallel beam of light ; the same voltage (12 volts) was always supplied from a slide wire potentiometer, connected to a storage battery. Between the slit and the emulsion bottle was placed an air-tight rectangular bottle, containing $1N$-$CuSO_4$ solution to absorb heat rays and ultraviolet rays as suggested by Morse (*Trans. Faraday Soc.*, 1936, **32**, 941). In close contact with the emulsion bottle was placed a photo-electric cell (potassium) fitted up in a wooden box with a thin glass window. The light from the slit, after passing through the $CuSO_4$ solution and the· upper portion of the cream-zone of the emulsion, fell on the photo-electric cell. A similar glass bottle having the same dimensions and containing dehydrated glycerine was every now and then placed in the same position as the emulsion bottle, to test the constancy of the intensity of light. The change in the electric current, produced in the photo-electric cell, was measured by means of a D'Arsenol mirror galvano-meter. On allowing the transparent emulsion to stand, the cream-zone opposite the slit became more and more opaque owing to the increase of concentration of the disperse phase. The changes in current with time, as shown in Table I, in terms of scale divisions, being proportional to those in opacity, plotted against time, give the accumulation curve

The size-frequency curves are obtained by plotting radius of the particles against d_s/d_r, obtained from the time-accumulation curve according to the method of Kraemer and Stamm (*loc. cit.*) ; the radius of the particle (r) is calculated from Stokes law,

$$r = \sqrt{\frac{9h\eta}{2(S_p - S_d)gt}}$$

where $h =$ height of the cream-zone, $\eta =$ viscosity of the continuous phase at 35°, S_d denotes density of the disperse phase, S_p, the density of the continuous phase, g, the gravity constant, and t, time in minutes at which the reading of the mirror galvanometer was taken ; d_s is the distance between the ordinate intercepts of the two successive tangents to the time-accumulation curve, d_r is the difference between the radii, calculated at the two corresponding successive times. The area, bounded by any portion of the size-frequency curve and the abscissa, corresponds to the actual weight of the disperse phase with particles whose radii vary between the values represented by the bounding abscissa. The size-frequency curves for the

emulsions containing various quantities of KCl and KI, are shown in Figs. 1 and 2 respectively ; the bounded area decreases with increase in concentration of KCl, KBr and K_2SO_4 ; in case of KI and KSCN there is a slight increase in area, bounded by the size-frequency curves, with the increase in concentration of the salt. The viscosities of the continuous phases, determined by Ostwald's viscometer, interfacial tensions between the two phases of the emulsions, determined by stalagmometer (drop-weight method) and the maxima of the size-frequency curves in presence of various quantities of different salts are shown in Table II.
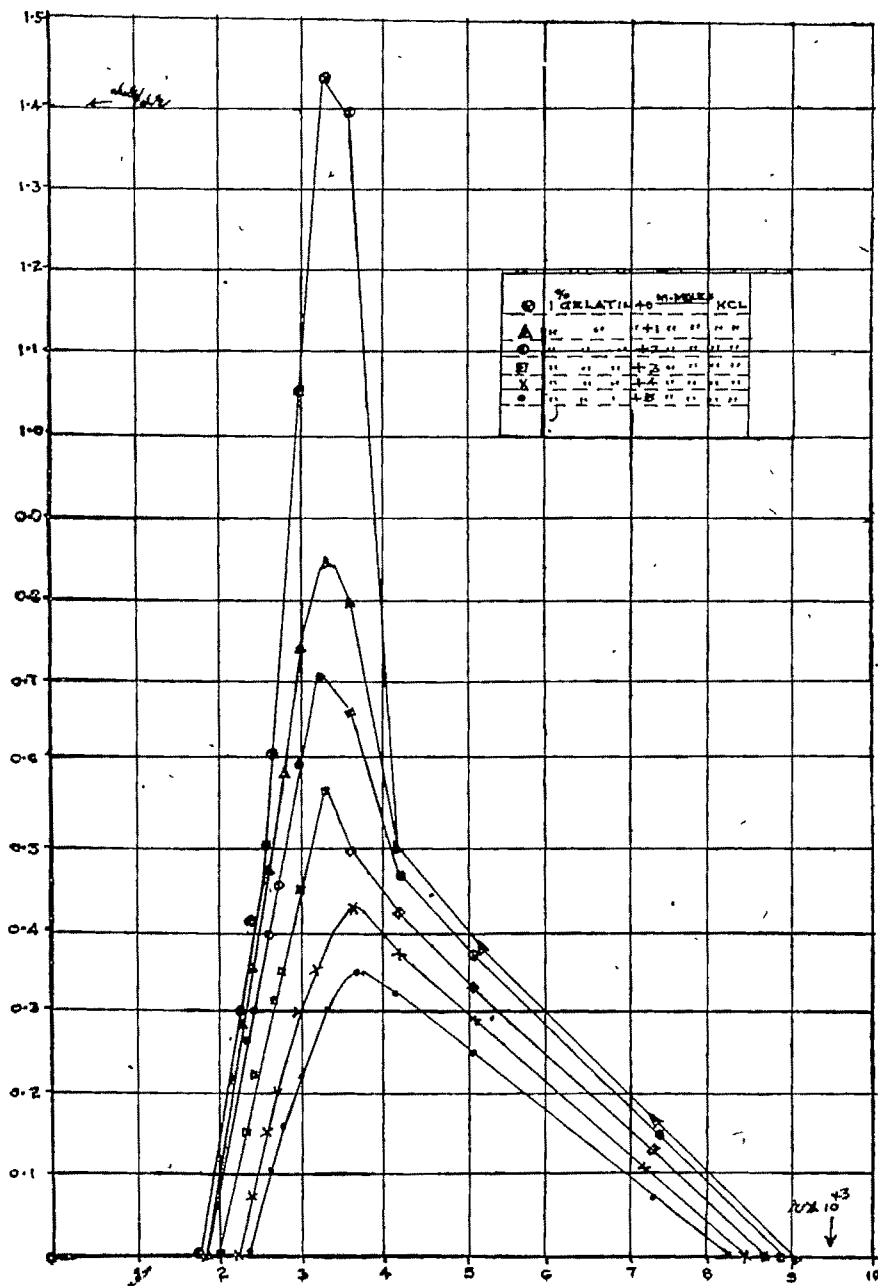
Fig. 1.

Size-frequency curve (KCl)

TABLE I

5 Millimoles of salt were added to 1% gelatin sol. 50% transparent emulsion of amyl acetate prepared and allowed to cream. The decrease in deflection of the mirror galvanometer in terms of scale divisions with time is shown below against each salt.

| Time.	No salt added.	K_2SO_4.	KCl.	KBr	KSCN.	KI.
30 min	06	03	03	08	11	12
60	09	05	05	05	18	18
90	12	06	07	07	21	22
120	15	07	08	08	24	24
150	17	08	09	10	25	26
180	20	09	10	11	26	27
240	22	11	12	13	28	29
300	24	12	14	15	29	31
360	25	13	15	16	30	31.75
420	26	14	16	17	31	32
540	27	15	17	18	32	83
1320	28	16	20	20	34	34
1440	28	16	20	20	34	34

TABLE II

Salt added to 100 c.c. of 1% gelatin sol.	Relative viscosity.	Interfacial tension.	Maxima of S.-F. curve.	Relative viscosity.	Interfacial tension.	Maxima of S.-F. curve.	Relative viscosity.	Interfacial tension.	Maxima of S.-F. curve.
	Pot. sulphate.			Pot. chloride.			Pot bromide.		
0 mM.	5.879	17.15	1.38						
1	6.185	17.13	0.70	5.908	17.10	0.85	5 912	17.13	0.95
2	6 181	17.02	0.63	5.933	17.05	0.71	5.943	17.10	0.82
3	6.220	16.94	0.50	5.960	17.01	0 57	5 968	17.06	0.65
4	6.276	16 85	0.40	5.990	16 98	0.43	6 005	17 01	0.54
5	6.327	16 79	0.34	6.030	16.94	0 35	6.043	16.95	0.48
	Pot. iodide.						KSCN.		
1 mM.	5.975	17.26	1.40				5.987	17 22	1.38
2	6.001	17.39	1.41				6.009	17.30	1.38
3	6.029	17.52	1.43				6.017	17.39	1.40
4	6.077	17.51	1.45				6.026	17.47	1.41
5	6.049	17.74	1.47				6 039	17.57	1.42

DISCUSSION

Table I shows that the rate of creaming, as measured by the increase in opacity due to arrival of more disperse phase in the cream-zone, decreases on addition of K_2SO_4, KCl, and KBr, while it increases on addition of KSCN and KI. Since

there is a gradual increase in opacity and it is very small within the interval between 540 and 1320 minutes, there must be no change in size of the particle of the previously formed cream-zone with time.

FIG. 2.

Size-frequency curve (KI)
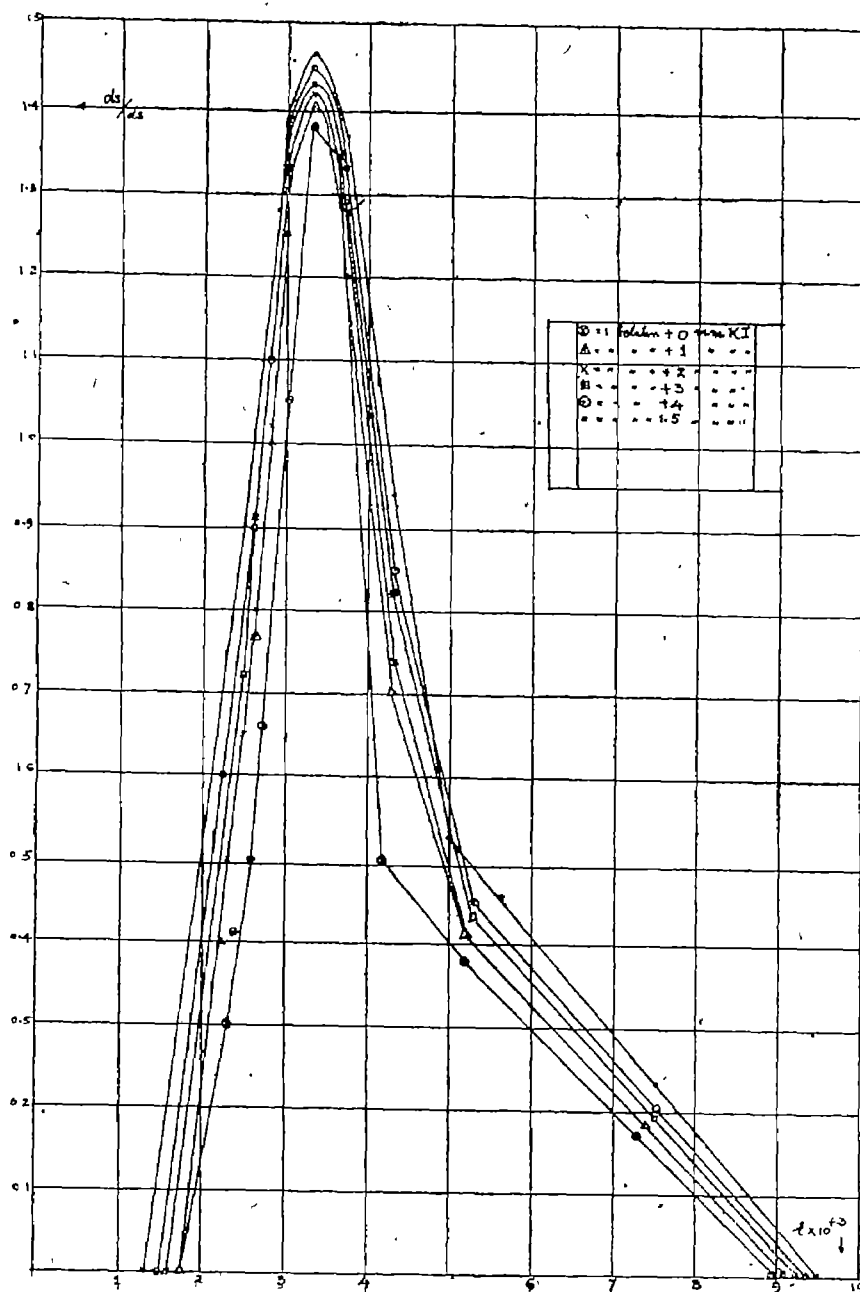
It is seen from Fig. 1 that on addition of KCl to the gelatin-protected emulsion, there is a decrease in the maxima as well as in the total area bounded by the size-frequency curves. Table II shows that the viscosity of the continuous phase goes on increasing and interfacial tension between the continuous and disperse phase goes on decreasing with the addition of K_2SO_4, KCl and KBr. Since the changes in the interfacial tension can directly determine the changes in stability of the emulsions, it is concluded from the above-mentioned observation that the changes in the total area bounded by the size-frequency curves should give us an idea about the stability of the emulsions. Bearing this in mind it is concluded from these size-frequency curves that additions of small amounts of K_2SO_4, KCl or KBr increases the stability of the gelatin-protected emulsion in the order : $K_2SO_4 > $ KCl $>$ KBr.

In case of KI (Fig. 2) and KSCN, there is a slight but regular increase in the maxima (refer to Table II) as well as in the total area bounded by the size-frequency curves with increase in the concentration. The interfacial tension also increases with the increase in conentration. So addition of small amount of KI and KSCN decreases the stability in the order : KI $>$ KSCN.

The general observation is that the influence of addition of small amounts of the salts on the size-frequency of the particles as well as the stability of the gelatin-protected emulsion follows rigidly the same order as that on changes in interfacial tension.

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CHEMISTRY OF SUBSTITUTED RING COMPOUNDS.
PART II SYNTHESIS OF αγ−AND
αγγ−TRIMETHYL*CYCLO*PENTANONES

BY MUHAMMAD QUDRATI-KHUDA AND ASHUTOSH MUKHERJI

Several trimethyl *cyclo*pentanones have been synthesised. One of these is obtained from *iso*phorone, which is reduced to dihydro*iso*phorone and is subsequently oxidised. The trimethyladipic acid thus obtained is cyclised to a ketone which appears to be a mixture. *p*-methyl*cyclo*hexanone is methylated to trimethyl*cyclo*hexanone, which on oxidation gives αγ−trimethyladipic acid ; this is cyclised to αγ−trimethyl*cyclo*pentanone. A [third trimethyl*cyclo*pentanone has been synthesised from ββ-dimethyl-γ-acetylbutyric acid through its cyanohydrin and its corresponding lactonic acid, which on reduction gives αγγ−trimethyladipic acid. This acid on cyclisation gives αγγ-trimethyl*cyclo*pentanone. This ketone is found to be identical with that obtained from Clemmenson reduction of dimedone.

Some years ago one of us (M. Q. K.) in course of his studies on the Clemmenson's reduction of cyclic 1 : 3-diones obtained a monocyclic ketone from dimethyldihydroresorcinol which was different from the ketone obtained by Crossley (*J. Chem. Soc.*, 1903, **83**, 117 ; 1907, **91**, 80) and therefore it was presumed to be a new form of dimethyl*cyclo*hexanone (Qudrat-i-Khuda, *Nature*, 1933, **132**, 201). Elucidation of the constitution of the ketone was not then complete as the study included a thorough examination of the mechanism of reduction when Dey and Linstead published a paper on the same subject and claimed the ketone obtained by the reduction of dimedone to be trimethyl*cyclo*pentanone (*J. Chem. Soc.*, 1935, 1063). Our observation also points towards the same fact, and in elucidation of this. however, a number of experiments was undertaken which are now embodied in the present communication.

It is interesting to note that by the reduction of dimethyl*cyclo*hexane-dione by Clemmenson method, the first product apparently is a bridged bicyclic dione, which at the second stage undergoes pinacolone transformation and the resultant unsaturated ketone is then further reduced to one saturated homologue (III).

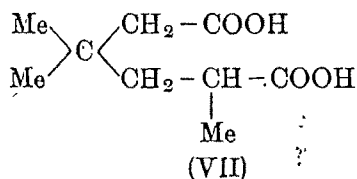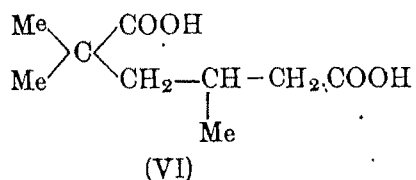$$(\text{ I }) \qquad\qquad (\text{ II }) \qquad\qquad (\text{ III })$$
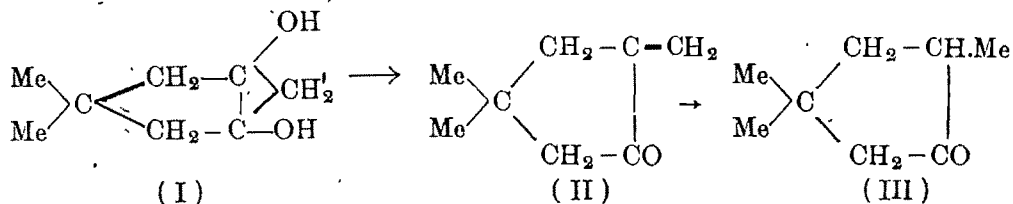
But a second portion of the dimethyldihydroresorcinol undergoes normal process of reduction and is converted into dimethyl*cyclo*hexane (IV, R = R′ = H).

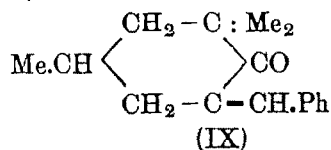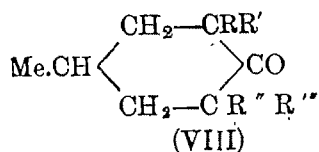$$(\text{ IV }) \qquad\qquad (\text{ V })$$
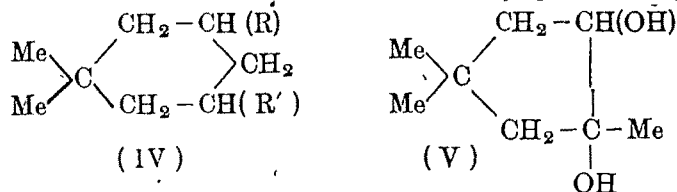
The yield of the saturated hydrocarbon is considerably affected by the time of contact of the dione with the solution, formation of the intermediate reduction product (I), and amalgamated zinc.. Probably dimedone is directly reduced to the hydrocarbon, more probably the intermediate diol (I) is reduced to the dihydro compound (IV, $R=R'=OH$), and (V), of which the former changes to dimethyl*cyclo*hexane (IV, $R=R'=H$), while the compound (V) passes into a ketone by the pinacolic transformation.

In order to settle the constitution of the trimethyl*cyclo*pentanone, a synthetic process starting with *iso*acetophorone appears to be a possible one. *iso*-Acetophorone is reduced to $\alpha\alpha\gamma$-trimethyl*cyclo*hexanone and subsequently oxidised to an acid, rather difficult to purify. The acid on cyclisation gives a ketone which is, however, found to be different from $\alpha\alpha\gamma$-trimethyl*cyclo*pentanone. On oxidation $\alpha\alpha\gamma$-trimethyl*cyclo*hexanone could give either the acid (VI) or the acid (VII). The ketone should therefore be either $\alpha\gamma\gamma$-or $\alpha\alpha\gamma$-trimethyl*cyclo*pentanone. The semicarbazone of the ketone melts at a definite temperature and after several crystallisations it does not undergo any change. We were rather surprised when the melting point of the semicarbazone of the ketone differed from those of either $\alpha\alpha\gamma$- or $\alpha\gamma\gamma$-trimethyl*cyclo*pentanone, and we proceeded to synthesise both these ketones by other unambiguous methods.

$$\begin{array}{c} Me \\ \diagdown \\ Me \diagup \end{array} C \begin{array}{c} \diagup COOH \\ \diagdown CH_2-CH-CH_2.COOH \\ \hspace{3em} | \\ \hspace{3em} Me \end{array}$$
(VI)

$$\begin{array}{c} Me \\ \diagdown \\ Me \diagup \end{array} C \begin{array}{c} \diagup CH_2-COOH \\ \diagdown CH_2-CH-COOH \\ \hspace{3em} | \\ \hspace{3em} Me \end{array}$$
(VII)

A very plausible method for the synthesis of the $\alpha\alpha\gamma$-trimethyl*cyclo*pentanone appears to be the distillation of $\alpha\alpha\gamma$-trimethyladipic acid or the cyclisation of the ester and subsequent hydrolysis. For the synthesis of this acid methyl*cyclo*hexanone has been methylated with sodamide and methyl iodide according to Haller and Cornubert (*Bull. soc. chim.*, 1926, iv, **39**, 1724). Subsequent methylation of dimethyl*cyclo*hexanone yields $\alpha\alpha\gamma$-trimethyl*cyclo*hexanone. The oxidation of this ketone is expected to yield $\alpha\alpha\gamma$-trimethyladipic acid. The methylation of dimethyl*cyclo*hexanone could, however, take place at the alternative methylene group and yield symmetrical trimethyl*cyclo*hexanone (VIII, $R=R''=H$; $R'=R'''=Me$). The trimethyl*cyclo*hexanone obtained from the two consecutive methylations gives with benzaldehyde (Ruzicka, *Helv. Chim. Acta*, 1925, **9**, 246) a very fine crystalline monobenzylidene compound (IX) which could not be obtained from the symmetrical compound. Hence the trimethyl*cyclo*hexanone should have the configuration (VIII, $R=R'=Me$; $R''=R'''=H$).

$$Me.CH \begin{array}{c} \diagup CH_2-CRR' \\ \diagdown CH_2-C R'' R''' \end{array} CO$$
(VIII)

$$Me.CH \begin{array}{c} \diagup CH_2-C : Me_2 \\ \diagdown CH_2-C-CH.Ph \end{array} CO$$
(IX)

On oxidation the ketone (VIII, R = R'= Me ; R" = R"' = H) gives a mixture of acids from which methylsuccinic acid and trimethyladipic acid could be separated by a few crystallisations. The identity of the trimethyladipic acid is confirmed by direct comparison with the acid, synthesised by Qudrat-i-Khuda and Ghosh (*J. Indian Chem. Soc.*, 1939, **16**, 287) and is found to be absolutely identical. The corresponding ketone is obtained from this acid by cyclisation or from the ester, when the keto-carboxylic ester is obtained which yields αα𝛾-trimethyl*cyclo*pentanone (X) The semicarbazone melts at 173°. The ketone is thus identical with that synthesised by Qudrat-i-Khuda and Ghosh (*loc. cit*).

$$Me.CH\underset{CH_2-CO}{\overset{CH_2-C:Me_2}{<}}$$

(X)
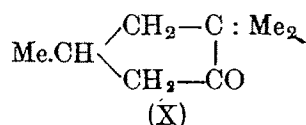
Attention has then been directed towards the synthesis of α𝛾𝛾-trimethyl*cyclo*pentanone Although it proved to be a rather difficult piece of work but ultimately we have been able to synthesise it. For this synthesis ββ-dimethylacetobutyric acid (XI) is converted into its cyanohydrin, when instead of the free cyanohydrin the corresponding lactonic nitrile (XII, R = CN) is obtained.

$$\underset{Me}{\overset{Me}{>}}C\underset{CH_2-COOH}{\overset{CH_2-CO.Me}{<}} \qquad \underset{Me}{\overset{Me}{>}}C\underset{CH_2-CO}{\overset{CH_2-\overset{\overset{R}{|}}{C}-Me}{<}}>O$$

(XI)   (XII)
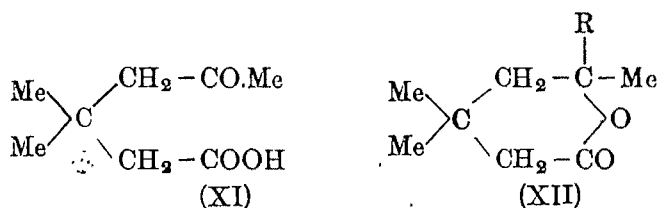
This is then hydrolysed to yield the lactonic acid (XII, R = COOH). The acid is esterified and is treated with phosphorus pentachloride and alcohol when the chloro-ester (XIII) is isolated.

$$\underset{Me}{\overset{Me}{>}}C\underset{CH_2-CO_2Et}{\overset{CH_2-CCl(Me)-COOEt}{<}}$$

(XIII)
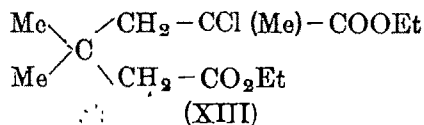
As it has been found to be difficult to remove this chlorine is the lactonic acid (XII, R = COOH) is subjected to direct reduction with hydriodic acid and red phosphorus, when αα𝛾-trimethyladipic acid (VII) is obtained. Although this acid melts at the same temperature as that obtained previously, yet there is a marked depression of melting point when mixed with a sample of trimethyladipic acid prepared from αα𝛾-trimethyl*cyclo*hexanone described earlier. On cyclisation the acid gives a ketone whose semicarbazone melts at 168° and there is no depression when this is mixed with the semicarbazone obtained from dimedone ketone. Thus the configuration of the ketone is definitely settled. It is expected that more interesting information may be obtained when other cyclic diones are examined later.

2

E X P E R I M E N T A L

Dihydro*iso*phorone was prepared by a suitable modification of Skita's method (*Ber.*, 1909, **42**, 1627) as follows :

*iso*Phorone (21 g.) and palladium chloride (0.6 g.) were mixed with distilled water (100 c.c.), heated till it dissolved, gum arabic (4 g.), dissolved in water (500 c.c.), alcohol (100 c.c.) and *iso*phorone (21 g.), prepared by the method of Knoevenagel and Tricker (*Annalen*, 1887, **297**, 185), were then added and the mixture was warmed to 80° and partially evacuated. It was then filled with pure hydrogen and shaken mechanically at the room temperature. At first the absorption was rapid and in course of 1 hour 2.5 litres were absorbed. The final absorption was 3.6 litres in course of 5 hours. Dihydro*iso*phorone boiled at 76°/23 mm., yield 19 g. It gave a semicarbazone, m.p. 204°.

Trimethyladipic Acid.—Dihydro*iso*phorone (50 g.) was oxidised by adding it dropwise to warm nitric acid (200 c.c., d 1.4) in course of 2 hours. When the addition had been complete, it was heated on a water-bath for about $1\frac{1}{2}$ hours. It was then poured into a shallow basin and concentrated. On cooling in ice, crystals separated out. The solid was separated from the mother-liquor and recrystallised from concentrated hydrochloric acid. Finally it was crystallised once more from ether and petrol and the product melted at 72°. (Found : C, 51.9 ; H. 7.7. $C_7H_{12}O_4$ requires C, 52.4 ; H, 7.5 per cent).

A portion of the acid remained in the liquid state and could not be induced to crystallise. It was esterified by alcohol and sulphuric acid. The ester was found to boil at 155-57°/42 mm., yield 52 g. from 50 g. of the acid. (Found : C, 63.3 ; H, 9.7. $C_{13}H_{24}O_4$ requires C, 63.9 ; H, 9.8 per cent). n_D, 1.42376 ; $d_4^{31.5}$, 0 95610. (R_L)$_D$ found, 64·98 ; calc. for $C_{13}H_{24}O_4$, 64.99

A little of the ester was hydrolysed by hydrochloric acid and the oily product after purification through the sodium salt and drying was left in a vacuum desiccator for nearly a fortnight when it solidified. This was crystallised from dry ether and found to melt at 72. [Found (in the silver salt) : Ag, 53·6. $C_9H_{14}O_4Ag_2$ requires Ag, 53 7 per cent].

Trimethylcyclopentanone Carboxylate.—Trimethyladipic ester (50 g.) was added to a cooled solution of sodium ethoxide (9.8 g. sodium in 200 c.c. alcohol) and after 3 hours the mixture was heated on a water-bath for 8 hours. Excess of alcohol was removed and ice added. The oily layer was extracted with ether, and washed several times with water, dried (calcium chloride) and the product isolated in the usual way. Trimethyl*cyclo*pentanone carboxylate boiled at 102-103°/4 mm., yield 31 g. The semicarbazone crystallised from methyl alcohol, m.p. 92°. (Found : C, 56.4 ; H, 8 2. $C_{12}H_{21}O_3N_3$ requires C, 56 5 ; H, 8 2 per cent). Ketone was regenerated from this semicarbazone by dilute hydrochloric acid (10%), b.p. 98°/4 mm. (Found : C, 66.3 ; H, 9.0. $C_{12}H_{18}O_3$ requires C, 66.6 ; H, 9.0 per cent) n_D, 1.42406 ; $d_4^{31.5}$, 0 9786. [R_L]$_D$ found, 51·64 ; calc for $C_{11}H_{18}O_3$, 51·53.

Trimethylcyclopentanone.—(*a*) The above keto-carboxylic ester (25 g.) was hydrolysed by concentrated hydrochloric acid (100 c.c.) on a sand-bath for 4 hours. The oily portion was extracted with ether, washed with a solution of sodium carbonate and water and dried (anhydrous sodium sulphate). Solvent was removed and distilled, b.p. 75-77°/45 mm., yield 12 g. It gave a semicarbazone very readily, which crystallised from dilute methyl alcohol, m.p. 155°. (Found : C, 59.0 ; H, 9.2. $C_9H_{17}ON_3$ requires C, 59.0 ; H. 9 4 per cent). The corresponding ketone was regenerated from the semicarbazone by heating it over a water-bath with dilute hydrochloric acid (10%), b.p. 76°/45 mm. (Found : C, 76.2 ; H, 11.0. $C_8H_{14}O$ requires C, 76.2 ; H, 11.1 per cent). n_D, 1·42175 ; $d_4^{31·5}$, 0.8828 [R_L]$_D$ found, 36·43 ; calc. for $C_8H_{14}O$, 36 78

(*b*) Trimethyladipic acid (10 g.) was intimately mixed with powdered baryta (0.7 g) and heated for 3½ hours in an air-bath first at 150°-160° and then at 300°-305° when an oily substance distilled over. It was extracted with ether and the ethereal extract was washed with a dilute solution of sodium carbonate and water. It was extracted with ether and the ethereal extract was washed with a dilute solution of sodium carbonate and water. It was dried and distilled and the ketone collected at 72°/42 mm , yield 3.6 g. It gave a semicarbazone, m.p. 155°. It is identical with the previous one.

Synthesis of ααγ-*Trimethylcyclopentanone*

*Preparation of αγ-Dimethyl*cyclo*hexanone.*—Methylcyclohexanone (22 g.) was slowly dropped on sodamide (10 g.), kept under dry ether (50 c. c.) in a three-necked flask provided with a mercury-sealed mechanical stirrer when a brisk evolution of ammonia began, and after the addition was complete (40 minutes), the flask was slightly warmed (33°) and kept warm for 2½ hours. When no more ammonia was evolved, the whole was cooled in ice, and methyl iodide (29 g., 12.6 c.c.) was added drop by drop and the mixture left overnight in a perfectly dry condition. Next day it was again warmed to 40° for 3 hours and then cooled in ice and ice-cold water was added to it from the dropping funnel. An oily layer separated which was collected and the aqueous portion was extracted twice with ether. The ethereal extract was then mixed with the original oil portion and the whole was washed with water, dilute hydrochloric acid, water, followed by a dilute solution of sodium thiosulphate and the solvent was removed. It was then fractionated under diminished pressure and dimethyl*cyclo*hexanone was found to boil at 90°/40 mm., yield 18 g. (*cf.* Haller and Cornubert. *loc. cit.*).

The semicarbazone crystallised from dilute methyl alcohol, m.p. 190°. A semicarbazone from 3-methyl*cyclo*hexanone was found to melt at 195° and a mixture of the two was found to melt at 176-77°.

Preparation of ααγ-Trimethylcyclohexanone from Dimethylcyclohexanone. —This methylation was effected exactly on similar lines as before. Dimethyl*cyclo*hexanone (25 g.) was methylated with powdered sodamide (10 g.) in dry ether

and then warmed for $2\frac{1}{2}$ hours. It was cooled and methyl iodide (26 g.) was added and the methylated product was isolated as before. The ketone boiled at 75°/25 mm. It formed a semicarbazone which crystallised from methyl alcohol, m p. 176°. (Found : C, 61.2 ; H, 9.6. $C_{10}H_{19}ON_3$ requires C, 60.9 ; H, 9.6 per cent). The ketone regenerated from the semicarbazone boiled at 72°/25 mm. (Found : C, 77.08 ; H, 11.4. $C_9H_{16}O$ requires C, 77.1 ; H, 11.4 per cent) d_4 $^{33.6}$, 0.8778 ; n_D, 1.43691 ; $[R_L]_D$ found, 41.78 ; calc., 41.5 per cent.

Benzylidene compound of ααγ-Trimethylcyclohexanone.—In a 500 c.c. three-necked flask provided with a mechanical stirrer was taken ααγ-trimethylcyclo-hexanone (4 g.) and freshly distilled benzaldehyde (12 g.), sodium hydroxide solution (10%, 40 c.c.) and rectified spirit (100 c.c.) and stirred for 3 days, keeping it at the room temperature. Water was then added to the mass after three days' stirring and the oil that separated was extracted with ether. The ethereal extract was washed thrice with sodium hydroxide solution (10%) and steam-distilled to remove the excess of benzaldehyde. The product after usual purification was treated with a little light petroleum (b. p 40°). When solidified, it was crystallised from ether and light petroleum, m.p. 82°. (Found : C, 84.2 ; H, 8.7. $C_{16}H_{20}O$ requires C, 84.2 ; H, 8.8 per cent).

Oxidation of Trimethylcyclohexanone with Nitric Acid : Preparation of ααγ-Methyladipic Acid.—The ketone (30 g.) was dropped to a mixture of nitric acid (100 c.c.) and water (50 c.c.) previously heated on the water-bath. The mixture was refluxed on the water-bath for 2 hours. The product ·was then poured into a shallow basin and concentrated on a water-bath. Water was added to it again and again till excess of nitric acid was completely removed. It was then kept inside a vacuum desiccator over fused calcium chloride and caustic potash and after keeping for 7 days it solidified to a waxy mass. This was spread over a porous plate and the solid was crystallised from dry ether, m.p. 79-80°. (Found : C, 57.5 ; H, 8.5. $C_9H_{16}O_4$ requires C, 57.4 ; H, 8.5 per cent).

Ethyl ααγ-trimethyladipate was obtained by esterification of trimethyladipic acid (66 g.) by heating on the water-bath for 12 hours with alcohol (300 c c.) and sulphuric acid (30 c. c). It was isolated as usual, b.p. 120-23°/10 mm., yield 75 g. (80% of theory). It was redistilled at 107°/3 mm. (Found : C, 63.6 ; H, 9 8. $C_{13}H_{24}O_4$ requires C, 63.9 ; H, 9.8 per cent). $d_4^{33.6}$, 0.9318 ; n_D, 1 41706 ; $[R_L]_D$ found, 65.63 ; calc., 65.30.

Trimethylcyclopentane Carboxylate.—Trimethyladipic ester (50 g.) was added slowly to an ice-cold solution of sodium ethoxide (4.6 g. sodium and 100 c.c. alcohol). It was then heated on the water-bath for 10 hours. Alcohol was removed from the water-bath as far as possible and crushed ice added to it It was next acidified with hydrochloric acid and extracted with ether. The ethereal layer was washed with water, and then with a dilute solution of sodium carbonate and again with water. It was dried (anhydrous sodium sulphate) and solvent was removed. Trimethylcyclopentanone carboxylate boiled at 94°/3 mm., yield 31 g. (75% of the

theory). The *semicarbazone* was prepared by heating it with semicarbazide hydrochloride in aqueous methyl alcohol solution with sodium acetate for 1 hour. The alcohol was removed and pieces of ice were added to it when a sticky solid mass separated out which was kept over porous plates. The solid was removed after a few days and was crystallised from benzene and petrol (b p. 55-60°) mixture, m.p 85-88°. Ketonic ester was regenerated from this semicarbazone by heating with dilute hydrochloric acid (10%) till all the solid dissolved in the acid and a clear layer of ketonic ester was found floating on water. It was cooled and then saturated with ammonium sulphate and extracted with ether. The ester was purified in the usual way, b p. 93°/3 mm. (Found : C, 66.5 ; H, 9.1. $C_{11}H_{18}O_3$ requires C, 66.6 ; H, 9.1. per cent). $d_4^{33·5}$, 0 9712 ; n_D, 1·42666 ; $[R_L]_D$ found, 52.26 ; calc., 52.34.

Hydrolysis of αα γ-Trimethylcyclopentanone Carboxylate : Preparation of αα γ-Trimethylcyclopentanone.—A mixture of the keto-ester (20 g.) and hydrochloric acid (30%, 75 c c.) and water (75 c.c) was heated on a sand-bath for 4 hours, cooled and then thoroughly saturated with ammonium sulphate. It was extracted with ether, the ethereal extract was washed with water, dried over anhydrous sodium sulphate and the solvent removed. The oily residue boiled at 73°/42 mm., yield 6.5 g. (52% of the theory). It was purified through its semicarbazone, m.p. 173°. (Found : C, 59.2 ; H, 9.3. $C_9H_{17}ON_3$ requires C, 59 0 ; H, 9 3 per cent). αα γ-Trimethyl*cyclo*pentanone boiled at 72°/42 mm. (Found : C, 76.5 ; H, 11.08. $C_8H_{14}O$ requires C, 76.2 ; H, 11.1 per cent). $d_4^{33·7}$, 0 9661 ; n_D, 1.42126 ; $[R_L]_D$ found, 36.89 ; calc., 36.95.

αα γ-Trimethylcyclopentane—Powdered trimethyladipic acid (10 g.) was thoroughly mixed with finely powdered baryta (0.7 g.) and distilled from an air-bath kept at 160°-180° for nearly 1 hour. The temperature was slowly raised to 320°-330° when the ketone distilled. The distillate was collected and diluted with ether, the ethereal extract was washed with a dilute solution of sodium carbonate and then with water and finally the solvent was removed and the oily residue was distilled at 70°/38 mm , yield 3.5 g (53% of theory). The semicarbazone melted at 173° (mixed m.p. with the semicarbazone of the ketone prepared before). The ketone was regenerated from the semicarbazone by treating it with dilute hydrochloric acid and extracting with ether, b p. 73°/42 mm.

Ethyl Carbethoxydimethyl-ketobutyrate.—To a well cooled solution of sodium ethoxide (2.3 g.) was added a mixture of malonic ester (160 g) and mesityl oxide (98 g.). It was then heated on the water-bath for 6½ hours after which alcohol was removed and the condensation product was isolated by dilution with water and extraction with ether. It was dried by fused calcium chloride and the residue after removal of the solvent was collected at

178-180°/38 mm., yield 78 g. (38-40%). (Found : C, 60.5 ; H, 8.5. $C_{13}H_{22}O_5$ requires C, 60 46 ; H. 8.51 per cent). $d_4^{33\cdot5}$, 0.1029 ; n_D, 1.4335 ; $[R_L]_D$ found, 65.34 ; calc., 65.31.

ββ-Dimethyl-γ-acetylbutyric acid was prepared by the hydrolysis of ethyl carbethoxydimethylacetylbutyrate with concentrated hydrochloric acid (30%, 400 c.c.) by heating on a sand-bath for 6 hours. It was then concentrated under reduced pressure, cooled and extracted with a cold and dilute solution of sodium carbonate. A solid substance separated out which was filtered off, and crystallised from dilute alcohol and was found to be dimedone. The sodium carbonate extract was next acidified, saturated with ammonium sulphate (solid) and extracted with ether. The ethereal extract was dried (anhydrous sodium sulphate), the solvent removed, and the residual oily layer was kept in a vacuum desiccator, but could not be induced to solidify, yield 51 g. (84% of theory). [Found (in the silver salt) : Ag, 40.5. $C_8H_{13}O_3Ag$ requires Ag, 40.8 per cent].

Dimethylhydroxycyanobutyric Acid and the corresponding Lactonic Acid.— Ethyl dimethylacetylbutyrate, prepared from the acid, using alcohol and sulphuric acid, was treated with a saturated solution of sodium bisulphite, but no solid bisulphite compound could be separated. The ester was next treated with an aqueous solution of potassium cyanide, and subsequently with concentrated hydrochloric acid according to the method of Welch and Clemo (*J. Chem. Soc*, 1928, 2629). But it could not be converted into the cyanohydrin. The solution of the acid (20 g.) in water (125 c.c.) was taken inside a 3-necked flask provided with a mechanical stirrer and a dropping funnel. The third end was fitted with a glass tube which was led to an efficient air-suction. The flask was cooled in a mixture of ice and salt and a solution of potassium cyanide (60 g. in 100 c. c. of water) was slowly dropped into the solution of the acid during 2 hours. It was then left within the freezing mixture for 2 hours with continuous stirring, after which concentrated hydrochloric acid (94 c. c., 30%) was very slowly added from the dropping funnel during 4 hours. It was then kept in ice overnight ; the cyanhydrin was extracted with ether and the ethereal solution was washed with water several times. After removal of the solvent, the residual oil was hydrolysed with concentrated hydrochloric acid (120 c. c, 30%) by heating on the water-bath for 12 hours. The aqueous solution was concentrated under reduced pressure at the temperature of the water-bath. A solid acid separated out which was filtered off and crystallised from a mixture of ether and petrol (b. p. 55-60°), m. p. 81°. (Found : C, 50.79 ; H, 7.3. $C_9H_{14}O_4$ requires C, 58.06 ; H, 7.5 per cent).

Reduction of the Lactonic Acid.—The lactonic acid (2 g) was mixed with red phosphorus (1 g.) and hydriodic acid (*d* 1 9, 12 c. c.) and heated in a sealed tube for 16 hours at 150°-160°. The acid was isolated as a thick syrupy residue after careful purification and removal of the solvent. The residue was triturated with water and separated from a small insoluble solid and finally water was removed

on a water-bath and then left in a vacuum desiccator for about 2 weeks The solid thus obtained crystallised from concentrated hydrochloric acid (30%), m. p. 71°. [Found : C, 57.3 ; H, 8.5. M. W. (by titration), 187 4. $C_9H_{16}O_4$ requires C, 57.4 ; H, 8.5 per cent. M. W., 188].

Ethyl αγγ-Trimethyladipate.—Trimethyladipic acid (12 g.) was esterified with absolute alcohol (80 c. c.) and concentrated sulphuric acid (*d* 1.84, 4 c. c.) by heating over a water-bath for 4 hours. The ester was isolated as usual, b p. 105°/4mm., yield 12 g. (75% of theory). (Found : C, 63.8 ; H, 9.7. $C_{13}H_{24}O_4$ requires C, 63.9 ; H, 9.8 per cent). $d_4^{31·5}$,0.9561 ; n_D, 1.42376 ; $[R_L]_D$ found, 64.98 ; calc., 64·99.

Ethyl αγγ-trimethyladipate (10 g.) and molecular sodium (0.8 g.) in benzene were heated under reflux for 6 hours on a water-bath. The reaction mixture was cooled and the product decomposed by ice. It was acidified by concentrated hydrochloric acid and extracted with ether. The ethereal extract was washed with water and then sodium carbonate solution and water, dried over anhydrous sodium sulphate, the solvent removed and trimethyl αγγ-*cyclo*pentanone-carboxylate collected at 98°/4 mm. Its semicarbazone separated out as a stricky mass which solidified in course of a few days. It was crystallised from very dilute methyl alcohol, m p. 92°. (Found : C, 56.4 ; H, 8.2. $C_{12}H_{21}O_3N_3$ requires C, 56 5 ; H, 8 2 per cent). The ketone was regenerated from the semicarbazone, when it boiled at 98°/4 mm. (Found : C, 66.3 ; H, 9.0. $C_{11}H_{18}O_3$ requires C, 66.6 ; H, 9.0 per cent). $d_4^{31·5}$, 0.9786 ; n_D, 1.42406 ; $[R_L]_D$ found, 51.64 ; calc., 51.53.

αγγ-Trimethylcyclopentanone.—Trimethyl*cyclo*pentanone carboxylate (10 g.) was hydrolysed with hydrochloric acid (30%, 100 c. c.) and water (30 c. c.) by heating for 4 hours. The liquid was then washed with ice-cold water and saturated with ammonium sulphate and extracted with ether. The ethereal extract was washed with a dilute solution of sodium carbonate, water, dried (anhydrous sodium sulphate), the solvent removed and the ketone collected at 75°/38 mm., yield 3.1 g (51% of theory) It gave a semicarbazone which crystallised from benzene, m.p. 168°. (Found : C, 59.2 ; H, 9.3. $C_9H_{17}ON_3$ requires C, 59.0 ; H, 9.3 per cent). The ketone was regenerated from the semicarbazone, b. p. 73°/37 mm. (Found : C, 76.2 ; H, 11.1. $C_8H_{14}O$ requires C. 76.1 : H, 11.1 per cent). $d_4^{33·8}$, 0.8752 ; n_D, 1·42506 ; $[R_L]_D$ found, 86·82, calc ; 36·95.

The same ketone was obtained by dry distillation of trimethyladipic acid (7 g.), intimately mixed with finely powdered baryta (0.7 g.) in an air-bath, kept at 180°. The temperature was gradually raised from 180°-310°, when the ketone was collected. The ketone thus obtained boiled at 73°/37 mm., yield 2.6 g. (52% of the theory). It gave a semicarbazone, m p. 168° and was identical with the ketone obtained by the other method.

Monobenzylidene compound of αγγ-Trimethylcyclopentanone was obtained by condensing the ketone (2 g.) and freshly distilled benzaldehyde (6 c. c.) in presence of sodium hydroxide solution (10 c. c., 10%) by mechanically stirring the mixture with rectified spirit (30 c. c.) for 75 hours. The mixture was diluted with water (100 c.c.) and the oily substance was extracted with ether. The ethereal extract was washed with a dilute solution of sodium hydroxide and the ether removed. The oily residue was distilled in steam and the residue in the flask dissolved in ether and purified in the usual way. The benzylidene compound solidified to a crystalline mass which crystallised from a mixture of dry ether and dry petrol, m.p. 76°. (Found : C, 83.9 ; H, 8.4. $C_{15}H_{18}O$ requires C, 84.1 ; H, 8.4 per cent).

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STUDIES IN THE NEGATIVELY CHARGED COLLOIDAL SOLUTIONS OF VARIOUS FERRIC SALTS. PART IV.

NEGATIVELY CHARGED FERRIC TUNGSTATE SOL

By Sukhdeo Prasad Mushran and Satya Prakash

Negatively charged ferric tungstate sols have been prepared by dispersing freshly precipitated ferric tungstate by caustic soda, in presence of glucose or glycerine. The empirical formula of the sol, peptised in presence of glucose is $18Fe_2O_3.Fe_2(WO_4)_3 H_2O$ and that of the sol peptised in presence of glycerine is $17Fe_2O_3. Fe_2 (WO_4)_3. 15H_2O$. Various other characteristics of the sols have also been investigated.

In previous parts Musharan and Prakash (*J. Indian Chem. Soc.*, 1946, **23**, 111, 391, 413) studied in details the composition and various properties of negatively charged ferric vanadate, borate and molybdate sols. In this paper we have described our experimental results with negatively charged ferric tungstate sols.

It has been observed by one of the present authors (Mushran, *Current Sci.*, 1946, **14**, 200) that when sodium tungstate is added to ferric chloride solution containing glucose, a yellowish white precipitate of ferric tungstate is obtained, which dissolves on shaking if ferric chloride be in excess. If this clear mixture be purified by dialysis and coagulated by electrolytes, it sets to a transparent jelly with slight opalescence. Evidently the jelly has come out of the positively charged ferric tungstate sol. Now we have observed that the ferric tungstate precipitate can be peptised by caustic soda in presence of glucose or glycerine, and the bright red sol thus obtained carries over the negative charge. The idea of peptisation can be had from the following figures.

Ferric chloride solution (1 to 3 c.c.) corresponding to 30.36 g. of Fe_2O_3 per litre), when mixed with 1.0 to 3 0 c.c. of 10% sodium tungstate solution in presence of 1.0 to 3.0 c.c. of 20% glucose solution, requires 1.6 to 3.7 c.c. of N-NaOH solution (total volume 10 c.c.) to bring about the complete peptisation in half an hour.

The same ferric chloride solution (1.0 to 3.0 c.c.), when mixed with 1.0 to 3.0 c.c. of 10% sodium tungstate solution in presence of 1.0 to 3.0 c.c. of glycerine, requires 1.1 to 3.8 c c. of N-NaOH solution (total volume 10 c.c.) to bring about the complete peptisation in half an hour.

EXPERIMENTAL

Sol A was prepared by mixing 50 c.c. of a ferric chloride solution (corresponding to 30.36 g of Fe_2O_3 per litre), 50 c c. of 10% sodium tungstate solution, 50 c.c. of 20% glucose solution and 70 c.c. of N-NaOH solution. The total volume was kept 250 c.c. The sol was dialysed for 5 days.

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Sol B was prepared by mixing 50 c.c. of ferric chloride (of the same strength), 50 c.c. of 10% sodium tungstate solution, 25 c.c. of glycerine and 67.5 c.c. of N-NaOH solution. The total volume was raised to 250 c.c. The sol was dialysed for 3 days.

Composition of the Sols

The amount of tungsten in a given volume of the sol was estimated as WO_3. To a known volume of the sol was added Merck's concentrated hydrochloric acid and a little nitric acid and the solution was warmed. Tungsten was thus precipitated as tungstic acid. A small amount of NH_4Cl was added to prevent the formation of colloidal tungstic acid, and the solution was again heated. The tungstic acid was allowed to settle down and then filtered. The precipitate was ignited slowly in an open platinum crucible and the residue was weighed as WO_3. After precipitation and filtration of the tungstic acid, concentrated ammonia was added to the filtrate and iron was precipitated as $Fe(OH)_3$. This was ignited in a platinum crucible and estimated as Fe_2O_3. The amount of tungsten in the combined state with iron was found by coagulating a known amount of the sol cataphoretically and also by potassium chloride, the coagulum was in both the cases separately collected, washed, and estimated for tungsten as WO_3. The combined iron corresponding to this amount of tungstate was calculated on the assumption that ferric tungstate was $Fe_2(WO_4)_3$. The rest of the iron must be present as hydrated ferric oxide. From the ratio of the free to the combined iron the empirical formula of the sol was calculated.

TABLE I

Per litre.	Sol A. Glucose sol	Sol B. Glycerine sol	Per itre	Sol A Glucose sol	Sol B. Glycerine sol
Total iron	3.5880 g.	2.8883 g	Free iron	3.3378g.	2.7279g.
Total tungstate (WO_3)	1.9600	2 7200	Viscosity of sol (30°)	0.00831	0.00866
Combined tungstate (WO_3)	1.5600	1.0000	Viscosity of water (30°)	0.00803	0.00803
Free tungstate (WO_3)	0.4000	1.7200	Water, bound	0.03826	0.88500
Combined iron	0.2502	0 1604			
Empirical formula	13 $Fe_2O_3.Fe_2(WO_4)_3.H_2O.$	17 $Fe_2O_3. Fe_2(WO_4)_3.15H_2O.$			

The sols were coagulated cataphoretically and by $N/2$-KCl, centrifuged, and the p_H values of the supernatant liquids were determined by Hildebrand hydrogen electrode. The following p_H values are recorded.

Glucose sol(A)	7.32 (KCl coagulated)	Glycerin sol (B)	76.2 (KCl coagulated)
	7.39 (Cataphoretically coagulated)		7.63 (Cataphoretically coagulated)

Specific Conductivities of the Sols

In the following table are recorded our observations on the conductivities of these sols at different temperatures, and dilutions and also the values on ageing.

TABLE IIa
Sp. conductivity at diff. dilutions (30°).

| Dilution. | Sp. condy. in mho | | Dilution | Sp. condy. in mho. | |
	Sol A.	Sol B		Sol A.	Sol B.
Sol (X) (original)	12.80×10^{-4}	25.20×10^{-4}	X/2	6.16×10^{-4}	13.46×10^{-4}
5X/6	10.26	21.42	X/8	4.15	9 82
2X/3	8.21	17.26	X/6	2.16	5.06

TABLE IIb
Sp. conductivity on ageing (30°).

Date.			Date.		
4.3.45	12.30×10^{-4}		24.8.45	12.39×10^{-4}	$25.73 \times^{-4}$
12.3.45	12.34	—	25. .45	—	The sol
14.8.45	—	25.20×10^{-4}	27.8 45	12.43	settles down
17.3.45	—	25.42	6 6.45	12.43	
21.3 45	—	25.68	2.7.45	12.46	

TABLE IIc
Sp. conductivity at different temperatures.

| Temp. | Glucose sol A | | Glycerine sol B | |
	Sp. condy.	Diff. per 5°	Sp. condy,	Diff. per 5°.
40°	14.70×10^{-4} mhos		29.86×10^{-4} mhos	
		1.20		2.34
35	13 50		27.52^{-4}	
		1.20		2.32
30	12.30		25.20	
		1.20		2.32
25	11.10		22.89	
		1.20		2.33
20	9 90		20.56	
Temp of zero conductance (extrapolated)		$-19.5°$		$-24.5°$
Temp. coefficient per 1°		0.240		0.466

From the above table it appears that in the case of the glucose sol A, the sp. conductivity runs proportional to dilutions, whilst in the case of the glycerine sol B, those at various dilutions are always higher than those computed on the basis of dilutions. The higher values of conductivity evidently suggest hydrolysis of . the sol. The sp. conductivities of both the sols increase with age. The sp. conductivity-temperature curves are straight lines.

Extinction Coefficients of the Sols

Extinction coefficients were determined by Nutting's spectrophotometer at different dilutions and at different wave-lengths. (X stands for the original undiluted sol).

TABLE III.

| Wave-lengths | Glucose sol (A) | | | | Glycerine sol (B) | | | |
| | X | Dilutions | | | X | Dilutions | | |
		X/2.	X/4	X/8.		X/2	X/4	X/5
5000 Å	—	3.66	1 83	0.93				
5200	4.64	2.32	1 16	0.58	3 12	2 09	1.44	1.33
54.0	2.86	1.44	0.72	0.36	2.54	1 44	1.13	0.83
5600	1.84	0.92	0.46	0.43	1.79	1.06	0.70	0.44
5800	1.25	0.62	0.31	0 16	1.14	0.66	0.59	0.30
6000	0.85	0.43	0.22	0.11	0.80	0.50	0.47	0 22
6200	0.68	0.34	0.17	0.09	0.61	0.44	0.43	0.14
6400	0 50	0.25	0.12	0.06	0.47	0.36	0.33	0.11
6600	0.40	0.20	0.09	0.05	0.38	0.26	0.20	0 09
6800	0.28	0 14	0.07	0 03	0.29	0.19	0.13	0.07

A scrutiny of the above table shows that in the case of the glucose sol A, Beer's law is almost rigidly followed, i e., the extinction coefficients are approximately proportional to the dilutions. In the case of sol B, the extinction coefficients are always higher than those computed on the basis of dilution. The hydrolysis of ferric tungstate under these conditions has no doubt caused deviations in the extinction coefficients-dilution relationship (cf. results on the sp. conductivities at different dilutions in Table IIA).

Coagulation of the Sols

In the following table are recorded the minimum amounts of electrolytes necessary to coagulate 1 c.c. of the sols in a total volume of 10 of c.c., the time allowed in each case being 30 minutes.

TABLE IV

Electrolytes.	Sol A.	Sol B.	Electrolytes.	Sol A.	Sol B.
	Amount necessary to coagulate			Amount necessary to coagulate	
$N/2$-NaCl	2.70 c.c.	2.00 c.c.	$N/250$-Ba $(NO_3)_2$	2 70 c.c.	1.60 c.c.
$N/2$-KCl	2 10	1.40	$N/250$-Sr $(NO_3)_2$	3.10	1.80
$N/2$-KNO$_3$	2.10	1.40	$N/250$-AlCl$_3$	1.50	1.80
$N/2$-KBr	2.10	1.40			

The coagulating power of the ions thus falls in the following series :
NaCl $<$KCl, KBr, KNO$_3$ $<$ Sr (NO$_3$)$_2$ $<$Ba (NO$_3$)$_2$ $<$AlCl$_3$

The effect of dilution on the coagulation values has also been investigated.

TABLE V

Total volume $=$ 10 c c.

Electrolytes.	Glucose sol A			Glycerine sol B		
	1 c.c.	2 c.c.	3 c.c.	1 c c.	2 c.c,	3 c c.
$N/2$-NaCl	2 70	2.80	2.90	2.00	2.50	3.00
$N/2$-KCl	2.10	2.20	2 30	1.40	1.48	1 58
$N/2$-KNO$_3$	2.10	2.20	2 30	1.40	1.48	1.58

From this table it is evident that the sol obeys the Schulze-Hardy rule for the coagulation with electrolytes. They show the normal behaviour with dilution. The dilute sol requires less amount of electrolyte to coagulate it in a specified time.

Positively charged Ferric Tungstate Sols

It was reported by Varma and Prakash (Z. anorg. Chem., 1932, 205, 241) that when sodium tungstate was added to a solution of ferric chloride, the precipitate of ferric tungstate formed was only slightly peptised by adding ferric chloride in excess, but the peptisation was sufficient to give a clear sol if glycerine or glucose was used as a peptising agent. The sol thus formed bears a positive charge. In Table VI are given our results on the compositions of some positively charged ferric tungstate sols.

Sol A was prepared by mixing 50 c.c. of ferric chloride solution (corresponding to 69.84 g. of Fe$_2$O$_3$ per litre), 20 c.c. of 10% Na$_2$WO$_4$ solution and 25 c.c.

of 20% glucose solution. The mixture was vigorously shaken and then dialysed for 3 days.

Sol B was prepared by mixing 50 c c. of ferric chloride solution (corresponding to 69.84 g. of Fe_2O_3 per litre) 40 c.c. of 10% Na_2WO_4 solution and 10 c.c. of 20% glycerine solution. The mixture was vigorously shaken and dialysed for 3 days.

Estimations of iron and tungsten were made in the same manner as in the case of negatively charged ferric tungstate sols.

<div align="center">TABLE VI</div>

| Per litre.	Sol A.	Sol B.
Total iron	7.8225 g.	7.5815 g
Combined tungstate	8.8000	16.1700
Combined iron	1.3310	2.5930
Free iron	6.4915	4.9885
Viscosity of sol	0 00855	0.00860
Viscosity of water	0.00803	0.00803
Water, bound	0.2249	0 2913
Empirical formula	$5Fe_2O_3.Fe_2(WO_4)_3 H_2O$	$2Fe_2O_3.Fe_2(WO_4)_3 H_2O$
Sol (A) contained	2.9710 g. of Cl' per litre.	
Sol (B) contained	2.9530 g. of Cl' per litre.	

<div align="center">D I S C U S S I O N</div>

When sodium tungstate is added to ferric chloride, ferric tungstate is precipitated according to the following equation,

$$2FeCl_3 + 3Na_2WO_4 = Fe_2(WO_4)_3 + 6NaCl.$$
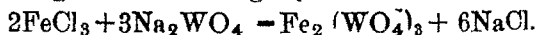
The precipitated ferric tungstate, though not easily peptised by caustic soda alone, goes to form a clear negatively charged ferric tungstate sol, if peptised in presence of glucose or glycerine by caustic soda. During the course of peptisation in presence of alkali ions, a part of ferric tungstate precipitated may undergo hydrolysis according to the following equation,

$$xFe_2(WO_4)_3 + 6yNaOH \leftrightarrows (x-y)Fe_2(WO_4)_3. yFe_2O_3 + 3yNa_2WO_4 + 3yH_2O.$$
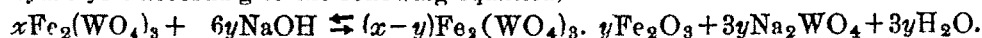
During the course of dialysis ferric tungstate further hydrolyses and the composition corresponds to higher ferric oxide content :

$$xFe_2(WO_4)_3 \leftrightarrows x' Fe_2(WO_4)_3. yFe_2O_3 \rightleftarrows y'Fe_2O_3$$
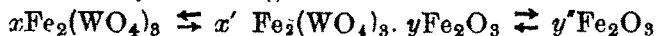
The negatively charged sols of ferric tungstate investigated in this paper had the following compositions. For comparison the compositions of some positively charged sols are also given :

Negatively charged sols :	Positively charged sols :
(a) $13Fe_2O_3. Fe_2(WO_4)_3. H_2O$	(a) $5Fe_2O_3.Fe_2(WO_4)_3.H_2O$
(b) $17Fe_2O_3. Fe_2(WO_4)_3. 15H_2O$	(b) $2Fe_2O_3. Fe_2(WO_4)_3. H_2O$

From the compositions given here, it is clear that the positively charged sols contain proportionately a higher content of ferric tungstate. The negatively charged sols were prepared mainly in the alkaline medium. Even after dialysis the pH of the supernatant liquids obtained after the coagulation of the sols lie between 7.32 and 7.63. The sols prepared were sufficiently alkaline. This accounts for the larger proportion of ferric oxide in the negatively charged sols.

As discussed in Part I (*loc. cit.*) it will be interesting to study the temperature coefficients of conductivity of negatively charged ferric tungstate sols. The temperature coefficients are given below with the [corresponding conductivities at 35°.

	Conductivity at 35°.	Temp co ffir. per 1°
Sol (A)	18.60×10^{-4} mohs	0.240
Sol (B)	27 52	0 466

The temperature coefficent of sol A is thus 1.77% of the conductance at 35°, and that of sol B is 1.69% of the conductance at 35°. The temperature coefficients are thus always less than 2% of the conductances at 35°

CONCLUSION

From the results recorded in the foregoing tables the following observations may be summerised.

(*i*) The conductivity of the glucose sol is very approximately proportional to the dilution, whilst the conductivity of the glycerine sol does not decrease in the same proportion as the dilution. This deviation from the dilution rule indicates marked hydrolysis of the glycerine sol.

(*ii*) The electrical conductivities of both the glucose and glycerine sols are linear functions of temperatures. The temperatures of zero conductance lie between -19.5° and -24.5°.

(*iii*) The temperature coefficients of conductivities per 1° of the sols are always less than 2% of the conductances at 35°.

(*vi*) The results on the ageing effect on the conductivities of the sols show increase of conductivities as the time proceeds.

(*v*) The changes in the extinction coefficients with dilution show that whilst Beer's law is observed in the case of glucose sols, it is not followed in the case of glycerine sol. The extinction coefficient in the case of glycerine sol does not decrease in the same proportion as the dilution indicating hydrolysis of the sol on dilution.

(*vi*) The sols obey the Schulze-Hardy rule for the coagulation of electrolytes. They show the normal behaviour on dilution.

(*vii*) The pH values of the dispersion medium lie between 7.22 and 7.63 showing that the sols are slightly basic owing to the stabilising hydroxide ions.

STUDIES IN MICHAEL CONDENSATION. PART I.

By Sailendra Mohan Mukherjee and Bidyut Kamal Bhattacharyya

The condensation of crotonaldehyde and cinnamaldehyde with acetoacetic ester in presence of traces of sodium ethoxide furnished substituted *cyclo*hexanone derivatives.

During the Michael condensation between an $\alpha\beta$-unsaturated aldehyde and a reactive methylene group in presence of a basic catalyst, the elimination of a molecule of water is presumably the first step of a series of complex reactions as shown by Knoevenagel (*Ber.*, 1898, **31**, 730 ; *J prakt. Chem*, 1918. *ii*, **97**, 288) Farmer and Mehta (*J. Chem. Soc.*, 1931, 2561) and Meerwin (*Annalen*, 1904, **336**, 339 ; 1908, **358**, 71 ; **360**, 327). But the normal Michael condensation between crotonaldehyde, cinnamaldehyde and acetoacetic ester was successfully carried out as described below.

Crotonaldehyde (I, R = Me) has been condensed with acetoacetic ester in alcoholic solution at -10° to -5° in presence of traces of sodium ethoxide to obtain (II, R = Me) together with a considerable portion of a higher boiling fraction. When the above reaction is carried out in presence of a molar quantity of sodium ethoxide, only the higher boiling product was formed in conformity with the observation of the above workers. The above compound (II, R = Me) is hydrogenated and the resulting compound (III, R = Me) hydrolysed and decarboxylated to yield *m*-methyl*cyclo*hexanone (IV. R = Me) whose identity has been confirmed by the mixed m.p. of its semicarbazone with an authentic specimen of the same.

The above condensation has been carried out with cinnamaldehyde (I, R = Ph) to produce (II, III and IV where R = Ph).

The above reaction has been studied in order to prepare the intermediate compounds to build up the fully and partially hydrogenated *cyclo*pentano-perhydro-phenanthrene derivatives.

(I)   (II)

(III)   (IV)
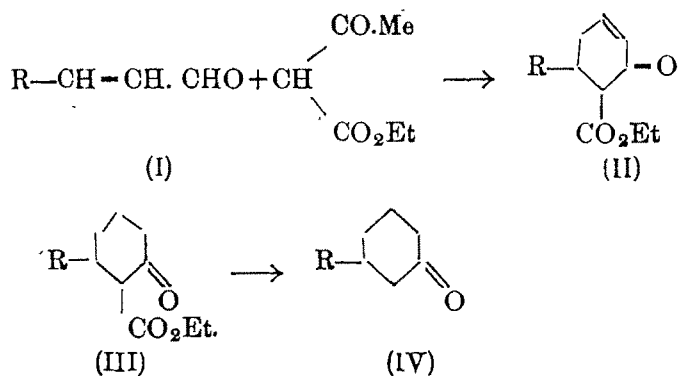
<center>EXPERIMENTAL.</center>

Ethyl 3-Methylcyclohex-5-ene-1-one-2-carboxylate.—A solution of sodium ethoxide prepared from sodium (0.1 g.) and alcohol (50 c c.) was taken in a three-necked flask fitted with a mercury-sealed stirrer, thermometer and a dropping funnel and cooled in a freezing mixture. While the temperature of the alkoxide was falling, acetoacetic ester (27 g.) was poured in and the stirring was commenced. . When the temperature of the reaction mixture was cooled down to -10°, a solution of freshly distilled crotonaldehyde (14 g.) in alcohol (90 c.c.) was added drop by drop. The stirring was stopped after the addition was complete. Towards the end the tempera-ture of the content reached -5°. The alcohol was removed under reduced pressure (water-pump) when a red colour developed. The content was next poured into brine solution, extracted with ether, washed thrice with water and distilled under 6 mm. of pressure (a) 110-12°, (b) 112-4°, (c) 170-80°. On redistillation the follow-ing two main fractions were collected under 6 mm. of pressure, (1) 107-10°; (2) 165-72°. The first fraction contained the compound (II, R=Me) and gave greenish brown coloration with alcoholic ferric chloride, yield 3 g. (Found : C, 65.8 ; H, 7.6. $C_{10}H_{14}O_3$ requires C, 65.9 ; H, 7.6 per cent). Second fraction gave C, 66.6 ; H, 7.5%.

Ethyl 3-Methylcyclohexan-1-one-2-carboxylate.—The above unsaturated com-pound (5 g.) was hydrogenated in alcoholic solution with Adam's catalyst (0.1 g.) when calculated quantity of hydrogen (500 c c) was absorbed The catalyst was filtered and the solution was distilled, b.p. 122-25°/16 mm. A temporary violet colora-tion was obtained by treating the compound with alcoholic ferric chloride. (Found : C, 64.9 ; H, 8.5. $C_{10}H_{16}O_3$ requires C, 65 2 ; H, 8.7 per cent).

m-*Methylcyclohexanone.*—The above compound. (III, R=Me) was hydrolysed by refluxing with 20% sulphuric acid for 16 hours. It was extracted with ether, washed with sodium carbonate solution and distilled. The fraction coming over at 160-80° was collected and it furnished immediately a semi-carbazone. It was twice crystallised from dilute alcohol, m.p. 172°, (mixed m p. with an authentic sample, 172-73°). (Found : N, 25.02. $C_8H_{15}ON_3$ requires N, 24.85 per cent).

Ethyl 3-Phenylcyclohex-5-ene-1-one-2-carboxylate.—A solution of sodium ethoxide prepared from sodium (0.5 g.) and alcohol (120 c c.) was cooled to -10° and ethyl acetoacetate (52 g.) was added to the alkoxide solution. Next, a solution of cinnamaldehyde (52 g.) in alcohol (40 c.c) was added drop by drop to the mixture which was shaken constantly. The reaction mixture was kept overnight and then poured into brine solution and worked up as before, b.p. 162°/5mm., yield 17 g. It gave a red colour with alcoholic ferric chloride. (Found : C, 73.52 ; H, 6.45. $C_{15}H_{16}O_3$ requires C, 73.77 ; H, 6.55 per cent).

Ethyl 3-Phenylcyclohexan-1-one-2-carboxylate.—The above compound was hydrogenated in acetic acid solution as before, b.p. 155°/ mm. It gave a violet

coloration with alcoholic ferric choride. (Found : C, 72.91 ; H, 7.5. $C_{15}H_{18}O_3$ requires C, 73.17 ; H. 7.31 per cent).

m-*Phenyl*cyclo*hexanone.*—The compound (III, R = Ph) was refluxed with 20% sulphuric acid to yield 3-phenyl*cyclo*hexanone, b.p. 140°/6mm. (Found : C. 82.41 ; H, 8.1. $C_{12}H_{14}O$ requires C, 82.72 ; H, 8.05 per cent).

The above ketone furnished a semicarbazone, m.p. 169°(Lit. m p. 169-169.5° ; Boyd, Clifford and Prodeert, *J. Chem. Soc.* 1920, **117**, 1389). (Found : C, 67.01 ; H, 7.1. $C_{13}H_{17}ON_3$ requires C, 67.57 ; H, 7.57 per cent).

cyclo*Hex*-1-e*ne*-1-*aldehyde.*—*cyclo*Hex-1-ene-1-acid chloride (15.5 g.) in benzene (30 c.c.) was dropped in a mixture of quinoline (28 g.) and hydrocyanic acid generated from potassium cyanide (26 g.) and sulphuric acid according to the method of Grosheintz and Fischer (*J. Amer. Chem. Soc.*, 1941, **63**, 2021). The reaction mixture was worked up also according to the above procedure, b.p. 76°/17 mm., yield 3 5 g. The aldehyde was very susceptible to aerial oxidation. It furnished a semicarbazone, m.p. 218° (decomp.) (Literature records m.p. 212-13° , Wallach and Isaac, *Annalen,* 1906, **347**, 337). (Found : N, 24.6. $C_8H_{13}ON_3$ requires N 25.15 per cent).

SIR P. C. RAY RESEARCH FELLOW'S LABORATORY
AND
PALIT LABORATORY OF CHEMISTRY,
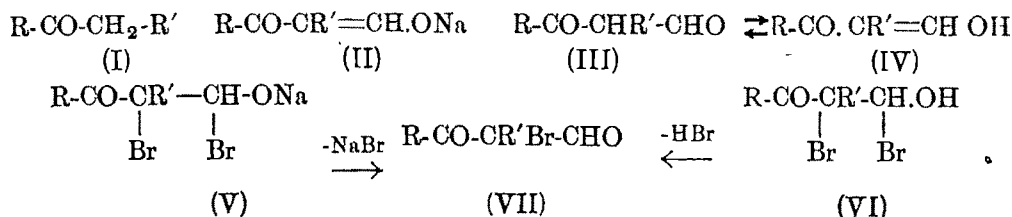UNIVERSITY COLLEGE OF SCIENCE AND TECHNOLOGY,
CALCUTTA.

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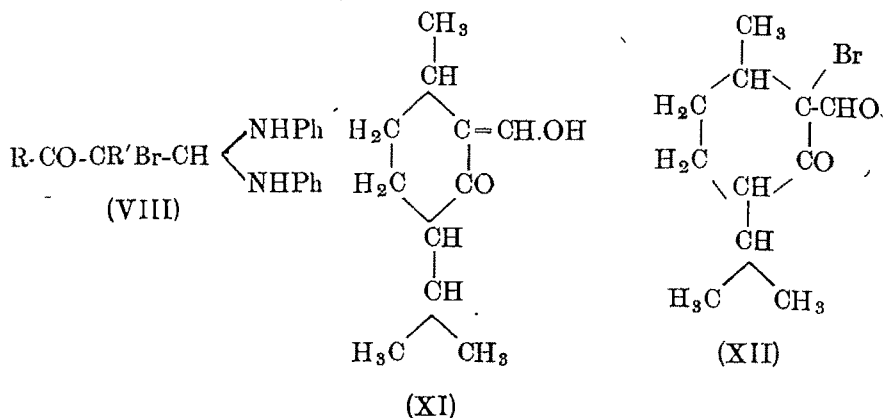# SYNTHESIS OF α-BROMO-β-KETO-ALDEHYDES FROM OXYMETHYLENE KETONES
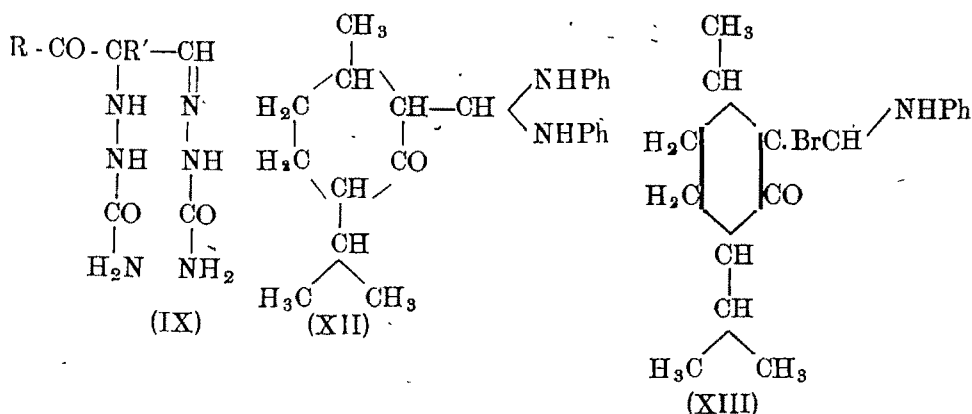
By M. S. Matta, R Kaushal and S. S. Deshapande

The action of bromine on sodium oxymethylene ketones in suspension of carbon tetrachloride or in aqueous solution results in the formation of α-bromo-β-keto-aldehydes which are characterised by the formation of anils and semicarbazones. Sodium oxymethylene acetophenone, however, has given α-bromobenzoylacetaldehyde, m. p. 110°. Kurt Meyer's hypothesis of alcoholic bromine addition for the estimation of keto-enolic mixtures is established.

Mehta, Kaushal and Deshapande (*J. Indian Chem. Soc.*, 1946, **23**, 43) have brought forward evidence in support of the view advanced by Kurt Meyer that the action of bromine on a keto-enolic tautomeric mixture takes place in two stages. Thus in the case of the formyl derivative (III) of a ketone (I), these stages are the following giving finally α-bromo-β-keto aldehyde (VII).

$$R\text{-}CO\text{-}CH_2\text{-}R' \quad R\text{-}CO\text{-}CR'\!=\!CH.ONa \quad R\text{-}CO\text{-}CHR'\text{-}CHO \rightleftharpoons R\text{-}CO.CR'\!=\!CH\,OH$$

$$(I) \qquad\qquad (II) \qquad\qquad\qquad (III) \qquad\qquad\qquad (IV)$$

$$
\begin{matrix}
R\text{-}CO\text{-}CR'\!-\!CH\text{-}ONa \\
\mid \quad\quad \mid \\
Br \quad\quad Br
\end{matrix}
\qquad
\xrightarrow{-NaBr}
\;
R\text{-}CO\text{-}CR'Br\text{-}CHO
\;
\xleftarrow{-HBr}
\qquad
\begin{matrix}
R\text{-}CO\text{-}CR'\text{-}CH.OH \\
\mid \quad\quad \mid \\
Br \quad\quad Br
\end{matrix}
$$

$$(V) \qquad\qquad\qquad\qquad (VII) \qquad\qquad\qquad\qquad (VI)$$

α-Bromo-β-keto-aldehydes seem to be interesting substances as they do not seem to have been described in the literature. Since some of the oxymethylene ketones (IV, R' = H) containing the group CH = CH.OH undergo self-condensation to form trisubstituted benzene (Kaushal, Sovani and Deshapande, *J. Indian Chem. Soc.*, 1942, **19**, 115), the action of bromine has been studied on the sodium compounds (II) as well as on the free ketones (IV). It is convenient to handle sodium compound because in the reaction between a ketone (I) and ethyl formate in presence of metallic sodium, salt (II) of the enol (IV) separates as an ether-insoluble solid, which on subsequent decomposition with cold dilute acid liberates the free oxymethylene ketone. Moreover, as the sodium salt (II) itself absorbs bromine as readily as the oxymethylene ketone (IV), it is advantageous to work on the sodium salt itself thereby avoiding the intermediate stage of generating the oxymethylene ketone and yet the final product will be the same compound (VII) as could be obtained from the free ketone (IV).

(VIII)

(XI)

(XII)

R - CO - CR′—CH
  | ||
 NH N·
  | |
 NH NH
  | |
 CO CO
  | |
H₂N NH₂

(IX)

CH_3
|
CH
H_2C CH—CH $\langle$ NHPh / NHPh
H_2C CO
  CH
  |
  CH
H_3C CH_3

(XII)

CH_3
|
CH
H_2C C.BrCH $\langle$ NHPh
H_2C CO
 CH
 |
 CH
H_3C CH_3

(XIII)

When bromine dissolved in carbon tetrachloride is added to the carbon tetrachloride suspension of sodium compound of oxymethylene acetophenone (II, R = Ph, R′ = H) in excess under ice cooling, bromine is rapidly absorbed and sodium bromide separates. After distilling off carbon tetrachloride from the filtrate, a thick liquid containing bromine remains from which on standing a colourless crystalline solid separates melting at 110°. This is ᾱ-bromobenzoylacetaldehyde (VII, R = Ph, R′ = H) which like other aliphatic aldehydes reacts with two molecules of aniline giving the dianil (VIII, R = Ph ; R′ = H) melting at 266°. It also forms a semicarbazone containing no bromine of the probable structure (IX, R = Ph ; R′ = H) melting at 204°. In the formation of semicarbazone, two molecules of semicarbazide react with elimination of one molecule of water and one molecule of hydrobromic acid.

Similarly sodium compound of oxymethylene acetone (II, R = Me ; R′ = H) by the action of bromine gives a viscous liquid containing bromine which could not be purified. The viscous liquid is the impure ᾱ-bromoacetylacetaldehyde (VII, R = Me ; R′ = H) as it gives reactions of an aldehyde and readily forms a semicarbazone, m.p. 264°. It reacts with aniline like an aliphatic aldehyde giving the dianil (VIII, R = Me ; R′ = H) melting at 256°.

In the case of oxymethylene methylethyl ketone (IV, R = R′ = Me) whose structure has been determined by Kaushal and others (J. Indian Chem. Soc, 1941, 18, 479 ; 1942 19, 116 ; 1943, 20, 55), the sodium compound (II, R = R′ = Me) is dissolved in water and on addition of bromine water in slight excess a red oil separates which is characterised as ᾱ-bromo-ᾱ-methylacetylacetaldehyde (VII, R = R′ = Me) by its reactions and the formation of the dianil (VIII, R = R′ = Me), m.p. 260-61°.

The action of bromine on oxymethylene menthone (X), dissolved in alcohol and neutralised by caustic soda, was studied by Brühl (Ber., 1904, 37, 2176). He obtained an oil which could not be purified by distillation due to its decomposition. To this crude oil he gave the stucture (XI).

On treating an aqueous solution of the sodium compound of oxymethylene menthone with bromine water, the same oil, as was obtained by Brühl (*loc. cit.*) separates. The oil could not be purified by distillation and therefore it has been treated directly with aniline when the anil (XIII) separates immediately as a solid, which on crystallisation from glacial acetic acid melts at 270-71° with decomposition. The parent oxymethylene menthone (X) reacts with aniline in presence of anhydrous zinc chloride like an aldehdye to form the dianil (XII) melting at 255-56°.

Thus by the addition of bromine to sodium derivatives of oxymethylene ketone, suspended in dry carbon tetrachloride or dissolved in water, α-bromo-β-keto-aldehydes are formed as coloured viscous liquids which could not be purified by distillation because of their decomposition. In the case of oxymethylene acetophenone, the viscous oil solidifies and the pure solid melts at 110°. These aldehydes are stable and they condense with aniline to form crystalline anils which serve to characterise them. In some cases the semicarbazones of the aldehydes have been prepared and analysed.

It is therefore clearly established that in the estimations of enols in keto-enolic mixtures by the Kurt Meyer's method, bromine first adds to the enol forming a dibromide (VI), the latter then loses hydrobromic acid to form a bromo-ketone (VII).

EXPERIMENTAL

α-Bromobenzoylacetaldehyde (VII, R = Ph ; R′ = H).—Carefully washed sodium salt of oxymethylene acetophenone (5 g.), prepared by Claissen's method, suspended in carbon tetrachloride (1 : 5) and bromine dissolved in carbon tetrachloride (1 : 3) was gradually added in instalments under ice-cooling till the colour of bromine persisted. The sodium bromide formed in the reaction was filtered and on removing the solvent from the filtrate, a red liquid remained, a part of which on distillation under reduced pressure soon solidified and hence the remaining liquid was left overnight when it also solidified ; the latter on being rubbed on a porous plate became perfectly white. It could not be crystallised from any organic solvent and was purified by washing with petrol ether, m p. 110°, yield 1 g [Found : Br (gravimetric), 35.9 ; (volumetric), 35.6. $C_9H_7O_2Br$ requires Br, 35.2 per cent]

The bromo-aldehyde has got all the reducing properties and gives violet colour with alcoholic ferric chloride and on oxidation with nitric acid gives an oily product.

The *dianil* (VIII, R = Ph ; R′ = H) of α-bromobenzoylacetaldehyde was obtained by adding a small piece of anhydrous zinc chloride to the solution of bromo-aldehyde (1.5 g.) and a few drops of aniline in ether, when on rubbing with a glass rod the dianil separated as a pale yellow crystalline mass. It was crystallised from absolute alcohol as needles, m.p. 266-67°, yield 2 g. It contains bromine. (Found ; N, 7.5. $C_{21}H_{19}ON_2Br$ requires N, 7.1 per cent).

The *disemicarbazone* (IX, R—Ph ; R'—H) of bromobenzoylacetaldehyde was obtained by adding a little of the aldehyde to a solution of semicarbazide hydrochloride and sodium acetate. On adding a few drops of alcohol it went into solution giving a yellow colour. On rubbing and scratching, the semicarbazone separated as a yellowish white precipitate, which was filtered, washed with water and crystallised from aqueous alcohol, m. p. 204°. (Found : N, 30.2. $C_{11}H_{14}O_8N_6$ requires N, 30.2 per cent).

ⲁ-*Bromoacetylacetaldehyde* (VII, R—Me ; R'—H) was prepared exactly in the same manner as bromobenzoylacetaldehyde using 5 g. of organic matter free from sodium oxymethylene acetone, suspended in carbon tetrachloride (1:3). After the addition of bromine was complete, the sodium bromide was filtered and the carbon tetrachloride distilled off when the crude bromo-aldehyde remained as a red coloured liquid yield 2 g. (approx.). It gives all the reactions of an aldehyde and colour reaction with ferric chloride solution.

The *dianil* (VIII, R—Me ; R'—H) of bromo-acetaldehyde was prepared by adding aniline, dissolved in ether, to bromo-aldehdye (0.5 g.) in ether. On addition of a little anhydrous zinc chloride condensation with aniline took place and the anil separated as a yellowish precipitate. On crystallisation from absolute alcohol it came out as star shaped needles, m. p. 256°, yield 0 3 g. (Found : N, 8.8. $C_{16}H_{17}ON_2Br$ requires N, 8.4 per cent).

The *semicarbazone* of .bromoacetylacetaldehyde was prepared in the usual manner as a yellowish crystalline precipitate which after purification melted at 264°.

ⲁ-*Bromo-ⲁ-methylacetylacetaldehyde* (VII, R—R'—Me).—Ether-washed sodium compound of oxymethylene methylethyl ketone (5 g), prepared by Claissen's method, was dissolved in water and bromine water was added to it in gradual instalments till permanent red colour had attained. After sometime a red coloured liquid was seen at the bottom. This was extracted with ether and on distilling off the ether, the crude bromo-aldehyde was obtained as a brown liquid, yield nearly 1 g. It gives all the reactions of an aldehyde and is characterised by the formation of its dianil (VIII, R—R'—Me).

The *dianil* (VIII, R=R'—Me) was prepared by adding aniline dropwise to the above bromo-aldehyde when condensation took place with the evolution of heat The crude product was crystallised from glacial acetic acid as shining crystals, m. p. 260-61°. [Found : N, 8.5 ; Br. 22.8. $C_{17}H_{19}ON_2Br$ requires N, 8.1 ; Br, 23.0 per cent).

Sodium salt of oxymethylene menthone (X) was prepared by the method described by Bishop, Claissen and Sinclair (*Annalen*, 1894, **281**. 394) using for one molecule of menthone 1.25 moles of amyl formate and 1.25 atoms of sodium. Thus 8 g. of the sodium salt were obtained from 8 g. of menthone.

*2-Bromo-2-aldehyde-3-methyl-6-isopropyl-*1-*cyclohexanone* (XI).—To the aqueous solution of the sodium salt of oxymethylene menthone bromine water was gradually added till it did not absorb any more and gave a red colour. It was then extracted with ether and on distilling off the ether the bromo-aldehyde was left as a brown oil which gave the reactions of an aldehyde It decomposes on distillation.

The sodium salt was suspended in dry carbon tetrachloride and was treated with an excess of bromine in the same solvent like sodium oxymethylene acetophenone. On filtering the sodium bromide formed, the residual liquid after removal of carbon tetrachloride gave the same bromo-aldehyde as an oil. In both the cases bromo aldehyde was characterised by the formation of the anil (XIII).

The *anil* (XIII) was obtained by adding aniline in drops to the bromo-aldehyde (XI). On mixing well condensation took place with evolution of heat and a pale yellow solid separated which on crystallisation from glacial acetic acid came out as fine shining crystals, m.p. 270-71°. (Found : N, 4.6. $C_{17}H_{24}ONBr$ requires N, 4 2 per cent).

Action of Aniline on Oxymethylene Menthone : Formation of Dianil (XII)—On adding a small quantity of anhydrous zinc chloride to a solution of oxymethylene menthone and aniline in ether and rubbing with a glass rod, the dianil (XII) separated as a yellow solid which on crystallisation from alcohol melted at 255-56°. (Found : N, 8.4. $C_{23}H_{30}ON_2$ requires N, 8.0 per cent).

THE INTERACTION OF IODINE AND STARCH
PART II. IODIDE IONS IN THE COMPLEX

BY SUDHAMOY MUKHERJEE AND SUKHAMOY BHATTACHARYYA

Determinations have been made of the iodide ion contents of starch and amylose-iodine complexes, precipitated in the presence of various concentrations of potassium iodide. The ratio of iodide ions to iodine increases with concentration of potassium iodide employed but this increase is more marked in the amylose-iodine complex. The maximum value of the ratio, found for amylose-iodine complex, corresponds to that required for the formation of the triiodide ion. Prolonged washing of the complex leads to a partial removal of both iodine and iodide ions.

Baldwin, Bear and Rundle (*J. Amer. Chem. Soc.*, 1944, **66**, 111) state that iodide ions can enter the starch-iodine complex and that these displace some of the iodine molecules, thereby increasing the starch-iodine ratio in the complex. It has, however, been shown in Part I of this series (Mukherjee and Bhattacharyya, *J. Indian Chem. Soc.*, 1946, **23**, 121) that the starch-iodine ratio of the precipitated iodine complexes of starch or amylose remains independent of the concentration of potassium iodide in the reaction mixture at the time of precipitation and also remains practically unchanged on subsequent washing with solutions of salts like sodium chloride or sulphate. In view of these observations, it was considered to be of interest to make a quantitative study of the proportions of iodide ions present in the complex under different conditions.

EXPERIMENTAL

The starch or amylose complexes were precipitated in the manner described in Part I (*loc. cit.*). The iodide content of the complex was obtained by taking the difference between the total and free iodine contents. For the estimation of total iodine, the precipitated complex was oxidised with a mixture of potassium dichromate and sulphuric acid and the iodine was distilled off and absorbed in hot dilute sodium hydroxide solution from which it was again liberated by acidification and was titrated with standard thiosulphate solution. An all-glass apparatus, specially designed in this laboratory and described earlier by Basu and Goswami (*Science & Culture*, 1938, **4**, 299), was used for this purpose.

The determination of the free iodine in the complex by titration with sodium thiosulphate, prior to the estimation of total iodine by the above method, led to erratic results in the latter estimation. In order to obviate this difficulty, the free iodine content was calculated indirectly by using the constant ratio of starch to iodine found in separate experiments.

The accuracy of the distillation method, where this disturbing factor was absent, was found to be within ±1.0%, and it was verified by control experiments that the presence of starch did not introduce any significant error.

The data obtained for potato starch and for amylose isolated from the same starch are given respectively in Tables I and II.

TABLE I

Iodide content of potato starch-iodine complex

Starch taken.	Conc. of KI.	Iodine content of the complex Free (a)	Total (b)	Iodide content. (b − a)	Iodide/Iodine ratio $\left(\dfrac{b-a}{a}\right)$	Remarks
0.6281 g.	1.210 M	0.1270 g.	0 1687 g.	0 0417 g.	0.329	
0.4076	0.580	0 0815	0.1003	0.0188	0.231	
0.4505	0.176	0.0912	0.1064	0.0152	0.167	
0.3913	0 046	0 0792	0.0891	0 0099	0.125	
0 5408	1.210	0.0860	0.1111	0 0251	0.292	Pptd. complex washed 6 times with 10% $Na_2 SO_4$

TABLE II

Iodide content of amylose-iodine complex

Amylose taken.	Conc. of K I.	Iodine content of the complex Free (a)	Total (b)	Iodide content of complex (b − a)	Iodide/Iodine ratio $\left(\dfrac{b-a}{a}\right)$
0 3914 g.	1.21 M	0.0799 g.	0.1178 g.	0 0379 g.	0.474
0.3167	0.580	0.0646	0.0851	0.0205	0.318
0.3511	0.176	0.0741	0 0944	0.0203	0.274
0.3383	0.046	0.0680	0.0776	0.0096	0.141

DISCUSSION

The results given in Tables I and II show that the starch-iodine complex generally contains iodide ions, the proportion of which varies with the concentration of potassium iodide in the solution from which complex is precipitated. For a variation of the concentration of potassium iodide from 0.046 M to 1.210 M, the ratio of iodide ions to free iodine in the complex varies from 0.125 to 0.329 for potato starch and from 0.141 to 0 470 for amylose. It is significant that the maximum value of this ratio found for amylose approaches 0.50 which is the proportion required for the formation of the triodide ion.

The fact that the ratios of iodide to free iodine are systematically lower for potato starch than for amylose indicates that iodide ions enter into the non-amylose portion of the unfractionated starch with less facility than into amylose as present in the complex.

One sample of the precipitated starch-iodine complex was subjected to prolonged washing with 10% sodium sulphate solution in order to see if the iodide ions were removable by washing. This had the effect of raising the starch-iodine ratio from about 3.90 to 4.90, and of reducing the ratio of iodide to free iodine from 0.329 to 0.292. The relatively small change in the latter ratio indicates that both iodide ions and iodine molecules are removed simultaneously during prolonged washing. Further work on these lines is in progress.

Thanks of the authors are due to Dr. U. P. Basu for his interest in the work.

ON THE REACTIVE CHAIN-LENGTH OF STARCH (AMYLOSE) SYNTHESISED BY MUSCLE PHOSPHORYLASE

By Amiya Kumar Rai Chaudhury

Hanes observed that equilibria in phosphorylase systems were unaffected by alterations in the concentrations of starch. He inferred therefrom that starch solutions might contain some component in a highly disaggregated condition which may be chemically active and this component was maintained in a state of saturation. Since direct chemical analysis is not possible, we have tried to approach the problem of determining the nature of this component from theoretical side based on a new theory of phosphorylase action, recently put forward by the author.

In considering the equilibria in phosphorylase systems, Hanes (*Proc. Roy. Soc.*, 1940, B, **129**, 205) observed "A point of interest is that the equilibrium is not perceptibly affected by alterations in the concentration of starch. This would seem to indicate that the effective concentration of starch is independent of the total concentration. A possible explanation may be that the phase of the colloidal system in which the reaction occurs is maintained in a state of saturation in respect to a form of starch in true solution or in a highly disaggregated condition". It will be highly interesting if we can get some clue as to the nature of this component. Evidently, however, in a complex system like that of starch, it is futile to expect that a direct chemical analysis will be of any avail.

Now, synthesis of polysaccharide from glucose-1-phosphate is represented by the equation,

$$n. \text{ glucose-1-phosphate} \rightleftarrows \text{polysaccharide} + n \text{ inorganic phosphate.}$$
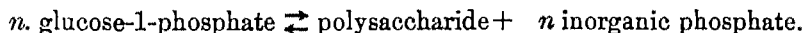
It has been shown in a previous paper (*J. Indian Chem. Soc.*, 1946, **23**, 193) that on the assumption that the reaction as written above is catalysed in the direction from left to right by the uncharged forms of the enzyme ($\overset{+-}{R}$ or HROH), whereas the reverse by the anions ROH$^-$, the ratio of the inorganic phosphate/organic phosphate (*i.e. F/P*) works out to be

$$k_0 \frac{\alpha}{\beta^{\frac{1}{n}}}$$

where $k_0 =$ constant,

$\alpha =$ mol. fraction of the enzyme in the form HROH

$\beta = \quad$ „ $\quad$ „ $\quad$ „ $\quad$ „ $\quad$ ROH$^-$.

It may be emphasised at the very outset that the value of 'n' will not necessarily be identical with the chain-length *i.e.* the number of glucose residues in the unit chain of the polysaccharide isolated. It is reasonable that 'n' corresponds to that component of starch system referred to by Hanes (*loc. cit.*) which will be effective in chemical reactions and must be used in mass law equations. 'n' may

therefore stand for what we may call· the "reactive chain-length of the pol. saccharide".

Now, $$F/P = k_0 \frac{\alpha}{\beta^{\frac{1}{n}}}$$ ...   ...   (1

taking logarithm

$$ln\,(F/P) = ln\,\,k_0 + ln\alpha - \frac{1}{n}\,ln\beta$$

differentiating with respect to [H⁺].

$$\frac{P}{F} \cdot \frac{d\,(F/P)}{d\,[H^+]} = 0 + \frac{1}{\alpha} \cdot \frac{d\,\alpha}{d\,[H^+]} - \frac{1}{n} \cdot \frac{1}{\beta} \cdot \frac{d\beta}{d\,[H^+]}$$

since, however, α has, in the regions of pH near the iso-electric, a maximum

value $\frac{d\,\alpha}{d\,[H^+]} = 0$, also we may replace $\frac{1}{\beta} \cdot \frac{d\beta}{d[H^+]}$

by its approximate value $-\frac{l}{[H^+]}$ l (see *J. Indian Chem. Soc.*, 1946, **23**, 193).

′ Therefore,

$$\frac{P}{F} \cdot \frac{d\,(F/P)}{d\,[H^+]} = \frac{l}{n\,[H^+]}$$ ...   ...   (2)

Now, since (P/F) values are known, as also F/P as a function of pH, we can calculate $d\,(F/P)/d$H

for,

$$\frac{d\,(F/P)}{d\,[H^+]} = \frac{d\,(F/P)}{d\,\log\,[H^+]} \cdot \frac{d\,\log\,[H^+]}{d\,[H^+]} = -\frac{d\,(F/P)}{d\,(p_H)} \cdot \frac{1}{[H^+]} \cdot \frac{1}{2.303}$$

also we can calculate 'l', which may equal the valence of the enzyme protein, from the mobility data of Green (*J. Biol. Chem.*, 1945, **158**, 315).

Knowing these values we can find out the value of 'n' from equation (2).

Calculation of the Valence of Phosphorylase-a (Muscle).—The relation between the charge and mobility of a sphere is given by Abramson, Moyer and Gorin ("Electrophoresis of Proteins", Chap. IV., p 123, equation 52) as

$$Q = \frac{6\pi\eta r\,\,(1 + \kappa r + \kappa r_i)\,v}{f(\kappa r)\,(1 + \kappa r_i)}$$ ...   .   (a)

where, v = mobility in cm/sec/volt/cm ; Q = charge in coulombs per molecule ; η = viscosity ; r = radius of the sphere ; r_i = "average" radius of ions in the ion atmosphere ; $\frac{1}{\kappa}$ = thickness of the double layer.

$$f\,(\kappa r) = \left\{ 1 + \frac{(\kappa r)^2}{16} - \frac{5}{48}\,(\kappa r)^3 - \frac{(\kappa r)^4}{96} + \frac{(\kappa r)^5}{96} - e^{-\kappa r}\left[\frac{12}{96}\,(\kappa r)^4 - \frac{(\kappa r)^6}{96}\right] \int_\alpha^{\kappa r} \frac{e^t}{t}\,dt \right\}$$

It is known, however, that the frictional ratio (f/f_0) for phosphorylase-a from muscle is somewhat higher than unity, but in view of the work of Adair and Adair (*Proc. Roy. Soc.*, 1936., B, **120**, 422) on the density of protein crystals, higher

frictional ratios may be due to hydration. For this reason as also for simplicity, we may take the enzyme molecules as approximately spherical for our present treatment.

Again, the radius of the protein sphere is given by the relation,

$$r = \frac{K\,T}{6\,\pi\,\eta D}$$

where,

$K =$ Boltzmann constant ; $T =$ absolute temperature ; $\eta =$ viscosity ; $D =$ diffusion constant.

From the data of Green and Cori (*J. Biol. Chem.*, 1943, **151**, 27), therefore,

$$r = \frac{(1.372 \times 10^{-16}) \times 293.1}{6 \times 3.142 \times 0.01118 \times 3.5 \times 10^{-7}} = 54.52 \times 10^{-8} \text{ cm.}$$

The value of κ at μ (ionic strength) $= 0.1$ is

$$\kappa = \sqrt{0.1}/3.06 \times 10^{-8} = 1.033 \times 10^7 \text{ cm}^{-1}.$$

Therefore,

$$\kappa r = (1.003 \times 10^7)\,(54.52 \times 10^{-8}) = 5.63$$

from Gorin's Table of values of $6/f\,(\kappa r)$ for various values of κr (Abramson, *et al.* "Electrophoresis of proteins" p 121),

$6/f\,(\kappa r)$ corresponding to 5.6 is $= 5.133$.

The average radius of electrolytic ions r_i is taken to be $= 2.5 \times 10^{-8}$ and $k r_i = 0.258$.

Substituting these values in equation (*a*) and remembering that the valence of the protein γ (the number of excess positive or negative charges per molecule in electronic units) would be obtained by multiplying v by the factor

$$(300/4.8 \times 10^{-10})$$

we get,

$$V = \frac{5.133 \times 3.142 \times 0.01118 \times 54.52 \times 10^{-8} \times (1 + 5.6 + 0.26) \times v \times 300}{1.26 \times 4.80 \times 10^{-10}}$$

$$= 3.345 \times 10^5 \times v$$

thus l is $\quad = 3.345 \times v \times 10^5$

Again from equation (2)

$$(P/F) \cdot \frac{d\,(F/P)}{d\,[\mathrm{H}^+]} = \frac{l}{n\,[\mathrm{H}^+]}$$

and since

$$\frac{d\,(F/P)}{d\,[\mathrm{H}^+]} = -\frac{d\,(F/P)}{d\,(p\mathrm{H})} \cdot \frac{1}{[\mathrm{H}\ ]} \cdot \frac{1}{2.303}$$

therefore,

$$(P/F) \times -\frac{d\,(F/P)}{d\,(p_{\text{H}})} \cdot \frac{1}{[\text{H}^+]} \cdot \frac{1}{2.303} = \frac{l}{n[\text{H}^+]}$$

or,

$$(P/F) = -l.\,\frac{2.303}{n} \cdot \frac{1}{m} \quad \text{where} \quad m = \frac{d\,(F/P)}{d\,(p_{\text{H}})}$$

$$= \frac{-3.345 \times (v \times 10^5) \times 2.3}{mn}.$$

If therefore we construct a graph (P/F) against $(v \times 10^5)$ *i.e.*, mobility $\times 10^5$, the slope of the straight line would be

$$= \frac{3.3 \times 2.3}{mn}.$$

From the actual graph (Fig. 1) it is found to be $= \frac{1}{9.3}$.

Therefore, $\quad n = -\dfrac{9.3 \times 3.3 \times 2.3}{m}.$

Also from the straight line (F/P) against p_{H} (Fig. 2),

$$m = \frac{d\,(F/P)}{d\,(p_{\text{H}})} = \quad -1.7,$$

which when put in the above equation, gives

$$n = \frac{9.3 \times 3.3 \times 2.3}{1.7} = 41.6.$$

Thus the active component of starch referred to by Hanes (*loc cit*) would be (glucose anhydride) $\backsim$ 40.
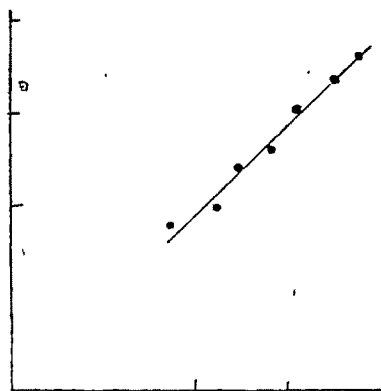

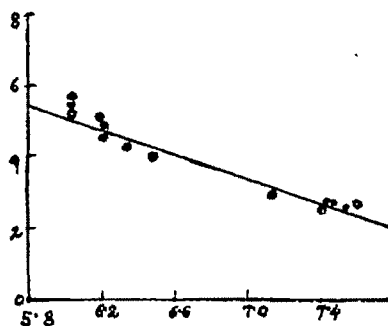Fig. 1.   Fig. 2.

It has been observed (*Ann. Rev. Biochem.*, 1944, **13**, 63) that starch may contain *iso*maltose linkings to the extent of one per 15-20 maltose linkings ; also all starch fractions give rise to β-maltose with β-amylase (Freeman and Hopkins, *Biochem. J.*, 1936, **30**, 451). One is therefore tempted to consider in view of the

fact that glucose-1-phosphate contains as α-linking, whether the occurrence of β-maltose linkages may not be responsible for the observed value of 'n'.

DISCUSSION

In deducing the relation,

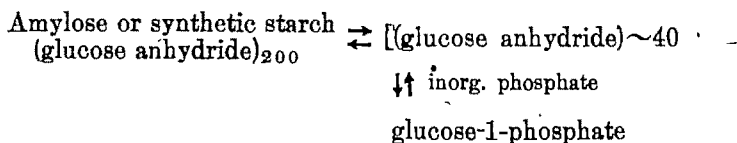$$\frac{1}{\beta} \cdot \frac{d\,\beta}{d\,[H^+]} = -\frac{l}{[H^+]}$$

(Rai Chaudhury, *J. Indian Chem. Soc.*, 1946, 23, 193) it will be found that we have neglected the variation of 'l' with p_H. But it is clear from the mobility—p_H curve (Green, *loc. cit.*) that in the regions near about the neutral, it is very flat *i.e.*, for large variations in $[H^+]$, 'l' changes by only a small amount. Hence omission of the term containing $\dfrac{dl}{d\,[H^+]}$ may not involve any serious error.

Next, we are required to add a few explanatory words about the action of muscle phosphorylase. It is known that the equilibrium

glycogen + inorganic phosphate ⇌ glucose-1-phoshhate
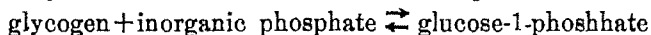
does not obtain (Rai Chaudhury, *loc. cit.*):
How can then our derivations be expected to hold true ? It may be recalled, however, that glucose-1-phosphate under the influence of muscle enzyme gives rise to a starch-like (amylose) polysaccharide with a chain length of 200 glucose units. Now, this synthetic polysaccharide can react with inorganic phosphate to give rise to glucose-1-phosphate. It stands to reason therefore that a true equilibrium such as synthetic polysaccharide + inorganic phosphate ⇌ glucose-1-phosphate actually takes place. From what has been stated earlier in the introductory portions, we may extend the idea further and make ont a scheme as follows :

Amylose or synthetic starch ⇌ [(glucose anhydride)~40 ·
(glucose anhydride)$_{200}$
↓↑ inorg. phosphate
glucose-1-phosphate

Lastly, we must add that the use of the experimental data of 'phosphorylase -a' has been deliberately made since 'phosphorylase-b' which is probably formed by the scission of adenylic acid from 'phosphorylase-a' is never active without adenylic acid.

In conclusion, I beg to offer my grateful thanks to Dr. D. M. Bose, our Director, for the constant interest and encouragement that I receive from him.

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SYNTHESES IN THE ACRIDINE SERIES. PART II. 4-METHOXY-6-CHLORO-9 (DIALKYLAMINOALKYL) AMINOACRIDINES

By Gurbakhsh Singh, Tara Singh and Mahan Singh

Seven N-substituted 4-methoxy-6-chloro-9-aminoacridines have been prepared.

The transfer of chlorine atom from position 6 to 7 in the aterbrin molecule [2-methoxy-6-chloro-9-(ω-diethylamino-*iso*butyl) aminoacridine dihydrochloride] has a dystherapeutic effect (Feldmann and Kopeliowitsch, *Arch. Pharm.*, 1935, **273**, 488), but it is not known how any change of the OMe group in the acridine molecule will affect the antimalarial properties. With this idea in view, a number of compounds of the type (I) has been prepared.
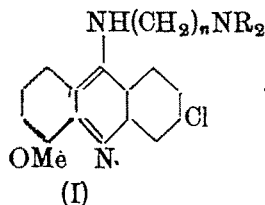
[where *n* is 3, 4 or 5 and R is ethyl, propyl, butyl or amyl].

(I)

The position of the chlorine atom has been maintained at 6, using a number of dialkylamino-alkylamino chains at position 9, while the OMe group has been shifted from position 2 to 4.

2 : 4-Dichlorobenzoic acid has been condensed with *o*-anisidine to give 5-chloro-6'-methoxydiphenylamine-2-carboxylic acid. This on treatment with phosphoryl chloride gives 4-methoxy-6 : 9-dichloroacridine. Condensation with the appropriate dialkylamino-alkylamine gives the required N-substituted 2-methoxy-6-chloro-9-aminoacridines.

EXPERIMENTAL

5-Chloro-6'-methoxydiphenylamine-2-carboxylic Acid.—A mixture of 2 : 4-dichlorobenzoic acid (19.1g.) (*J. Lahore Phil. Soc.*, 1945, **7**, 38), anhydrous potassium carbonate (20 g.), *o*-anisidine (18.5 g.), precipitated copper (0.2 g.) and dry glycerine (50 c.c.) was heated at 160° for 10 hours. The mixture was steam-distilled and the residue was filtered hot (charcoal). After cooling it was decomposed with dilute hydrochloric acid until acidic to Congo red. A deep violet mass appeared which was filtered and washed with hot water. The product was dissolved in ammonia (charcoal) and then decomposed with dilute hydrochloric acid. Another precipitation gave the acid as a cream coloured precipitate. After drying, it was crystallised from glacial acetic acid as buff coloured crystals, m. p. 205-06°, yield 60%. (Found : N, 5.05. $C_{14}H_{12}O_3NCl$ requires N, 5.04 per cent).

4-Methoxy-6 : 9-*dichloroacridine.*—The above acid (10 g.) was refluxed with freshly distilled phosphoryl chloride (80 c.c.) for 8 hours. Excess of phosphorus oxychloride was removed under vacuum and the residue treated with 10% solution of ice-cold ammonia. A greenish yellow mass was obtained, which after drying in a vacuum desiccator was crystallised from dry benzene as bright yellow needles, m. p. 189-91°, yield 70%. (Found : N, 5.18. $C_{14}H_9ON_2Cl_2$ requires N, 5.03 per cent). This acridine is unstable and changes to the corresponding acridone after sometime on exposure. For condensation, it was immediately used after crystallisation.

4-Methoxy-6-chloro-9-(γ-diethylaminopropyl)aminoacridine Dihydrochloride : (*General Method*).—4-Methoxy-6 : 9-dichloroacridine (2.78 g., 1 mol.) was dissolved in freshly distilled phenol (10 g.) and γ-diethylaminopropylamine (1.32 g., 1.1 mol.) was added. The mixture was heated at 100° for 3 hours. After cooling, it was poured into 150 c.c. of ether. Phenol was removed by washing with excess of 2N-sodium hydroxide solution. The yellow ethereal extract was filtered to remove any suspended acridone. The acridine base was extracted by shaking with excess of 5% acetic acid. The acetate solution after filtration was decomposed with alkali and the base was again shaken up in ether. After drying the ethereal extract over anhydrous potassium carbonate, the dihydrochloride was precipitated by addition of alcoholic hydrogen chloride. Extreme difficulty was encountered during the crystallisation of the hydrochloride, which usually separated as an oil. In one experiment, it was crystallised from a mixture of absolute methanol and ether as a yellow powder, m. p. 235-36° (decomp.). This observation could not, however, be repeated. The meconate was successfully prepared by treatment of the ethereal extract of the acridine base with a saturated solution of meconic acid in absolute alcohol. A yellow semi-solid was obtained which was thoroughly washed with ether. It was crystallised from absolute ethanol as a yellow powder, m. p. 160° (decomp.). It is quite soluble in water. (Found : N, 7.51. $C_{21}H_{26}ON_3Cl$. $C_7H_4O_7$ requires N, 7.34 per cent).

4-Methoxy-6-chloro-9-(δ-diethylaminobutyl)aminoacridine Dipicrate.—The hydrochloride as well as the meconate could not be crystallised, as they always separated as oils. The dry ethereal extract of the acridine base was concentrated till all ether had evaporated off. The residue was dissolved in dry benzene and treated with a solution of picric acid in benzene. A yellow semi-solid separated at once, which after trituration was converted into a powder. It was thoroughly washed with benzene, till the washings were colourless. The dipicrate was crystallised from absolute ethanol as a yellow microcrystalline powder, m. p. 191-92°. (Found : N, 14.78. $C_{22}H_{28}ON_3Cl.2C_6H_3O_7N_3$ requires N, 14.94 per cent).

4-Methoxy-6-chloro-9(ε-diethylaminoamyl)aminoacridine Dipicrate.—The dihydrochloride as well as the meconate could not be characterised. The picrate was twice crystallised from absolute ethanol as a yellow powder. It shrinks a little at 135° and melts at 151-53°. (Found : N, 15.08. $C_{23}H_{30}ON_3Cl$. $2 C_6H_3O_7N_3$ requires N, 14.69 per cent).

4-Methoxy-6-chloro-9-(γ-di-n-propylaminopropyl) aminoacridine Meconate.—
The dihydrochloride could not be crystallised. The meconate was crystallised from absolute ethanol as a light yellow powder, m. p. 183-85° (decomp.). It is freely soluble in water. (Found : N, 7.21. $C_{23}H_{30}O$ N_3Cl $C_7H_4O_7$ requires N, 7.0 per cent).

4-Methoxy-6-chloro-9-(γ-di-n-butylaminopopyl) aminoacridine Dipicrate.—
The dihydrochloride could not be crystallised. The meconate was prepared in the usual way, but during crystallisation from absolute ethanol, it was converted into white 4-methoxy-6-chloroacridone, m. p. 277-78°. (Found : N, 5.59. $C_{14}H_{10}O_2NCl$ requires N, 5.39 per cent). The picrate was crystallised from a large volume of absolute alcohol as a yellow powder, m. p. 196 98°. (Found : N, 14.01 $C_{23}H_{34}ON_3Cl$. $2 C_6H_3O_7N_3$ requires N, 14.23 per cent).

4-Methoxy-6-chloro-9-(γ-di-n-amylaminopropyl) aminoacridine Meconate.—
The dihydrochloride could not be characterised. The meconate was crystallised from absolute ethanol as a yellow powder, m.p. 205-06° (decomp.). It is soluble in water. (Found : N, 6.51. $C_{27}H_{38}ON_3Cl$. $C_7H_4O_7$ requires N, 6.40 per cent).

4-Methoxy-6-chloro-9-(γ-piperidinopropyl) aminoacridine dihydrochloride
was crystallised from a mixture of absolute ethanol and ether. It forms a stable hydrate which does not show a sharp melting point. It was crystallised thrice from absolute ethanol-ether mixture as a yellow powder. After drying in an air-oven at 100° for 3 hours, it melted at 240° with decomposition. It is freely soluble in water. (Found : N, 9.18. $C_{22}H_{26}ON_3Cl$. 2HCl requires N, 9.20 per cent).

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A NOTE ON THE SYNTHESIS OF α-n-DECYL-α-ETHYLSUCCINIC ACID

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In course of the investigations on phthioic acid, obtained from M. Tuberculosis, Robinson and his collaborators failed to condense ethyl cyanoacetate with decylethyl ketone (*J. Chem. Soc.*, 1942, 488). The above condensation has been carried out successfully according to the following conditions and thus a-decyl-a-ethylsuccinic acid has been prepared.

Decylethyl ketone was prepared following the method of Cason (*J. Amer. Chem. Soc.*, 1942, **64**, 1106). To the cold Grignard complex, prepared from ethyl iodide (41 g.), ether (150 c.c.) and magnesium (6.5 g.), cadmium chloride (25 g.) was added in portion and shaken. After some time ether was removed by heating on the water-bath and benzene (50 c.c., thiophene-free) was added and the benzene distilled off. Next the content of the flask was cooled and shaken vigorously with benzene (100 c c.) to disperse the solid cake at the bottom of the flask. A solution of the acid chloride of undecoic acid (35.8 g.) in benzene (40 c.c.) was added drop by drop to the cold reaction mixture with constant shaking. After the completion of the addition it was refluxed for 1 hour. It was next decomposed with iced dilute sulphuric acid and exhausted with benzene. The residue, left after removal of benzene, was refluxed for 2 hours with 5% alcoholic solution of potassium hydroxide (90 c.c.) and worked up in the usual way, b. p. 132-34°/10.5 mm., yield 22.8 g.

The above ketone (22.8 g.), ethyl cyanoacetate (12.9 c c.), ammonium acetate (4.46 g.), acetic acid (5.5 c.c.) and benzene (23 c.c.) were refluxed following the modified condition of Cope (*ibid.*, 1941, **63**, 3452), b. p. 192°/6 mm., yield 18 g. (Found : C, 73.29 ; H, 10.13. $C_{18}H_{31}O_2N$ requires C, 73. 37 ; H, 10. 58 per cent).

Diethyl α-Decyl-α-ethylsuccinate.—A solution of potassium cyanide (7.93 g.) in water (43.1 c.c.) was added dropwise to a solution of the above unsaturated cyano-ester (ethyl 2-cyano-3-ethyl- $\triangle^a$-tridecoate, 18 g.) in alcohol (70 c.c.) and) water (3.6 c.c.) with constant shaking. Next the content of the flask and a mixture of concentrated HCl (9.6 c.c.) and water (6.8 c.c.) were efficiently cooled in ice for 40 minutes. Then the acid solution was added drop by drop into the flask which was shaken constantly. The reaction mixture was left for another ½ hour and then poured into iced dilute HCl, exhausted with ether which was then driven off. The residue was refluxed with concentrated sulphuric acid (75 c.c.) and water (75 c.c. for 12 hours. It was then worked up in the usual way and subjected to alkaline hydrloysis by refluxing with aqueous solution of KOH (45 g., 25%) for 60 hours in

order to free it from nitrogen. It was worked as usual and the residue after removal of solvent was dried in vacuum. The dried residue was refluxed with alcohol (50 c.c.) and sulphuric acid (7 c.c.) for 70 hours, b. p. 170°/4 mm., yield 16 g. (Found : C, 69.9 ; H, 11.1. $C_{20}H_{38}O_4$ requires C, 70.17 ; H, 11.11 per cent).

α-*Ethyl-α-n-decylsuccinic Acid.*—The above ester was hydrolysed with 20% ethanolic KOH and worked up as usual. The crude acid was thrice crystallised from small amounts of glacial acetic acid, m.p. 84-86°. (Found : C, 66.97 ; H, 10.19. $C_{16}H_{30}O_4$ requires C, 67.13 ; H, 10.48 per cent).

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